



3.7 FISH

3.7 FISH	3-117
3.7.1 Introduction	3-118
3.7.2 Affected Environment	3-119
3.7.2.1 Life History of Priority Species	3-120
Chinook Salmon	3-127
Coho Salmon	3-127
Sockeye Salmon	3-127
Chum Salmon	3-128
Steelhead	3-128
Coastal Cutthroat Trout	3-128
Bull Trout	3-129
3.7.2.2 The Aquatic Ecosystem	3-129
Coarse Sediment	3-131
Fine Sediment	3-131
Hydrology	3-132
Large Woody Debris	3-132
The Aquatic Food Chain	3-133
Floodplains and Off-channel Habitat	3-134
Water Temperature	3-135
Forest Chemicals	3-136
Fish Passage	3-136
3.7.2.3 Regions of the State	3-137
Puget Sound	3-139
Olympic Coast	3-139
Southwest	3-140
Lower Columbia River	3-140
Middle Columbia River	3-140
Snake River	3-141
Upper Columbia River downstream of Grand Coulee Dam	3-141
Upper Columbia River upstream of Grand Coulee Dam	3-141
3.7.3 Environmental Effects	3-142
3.7.3.1 Issues and Evaluation Criteria	3-144
Coarse Sediment	3-145
Fine Sediment	3-145
Hydrology	3-145
Large Woody Debris	3-146
Leaf/Needle Litter Recruitment	3-146
Floodplains and Off-channel Areas	3-146
Water Temperature	3-146
Forest Chemicals	3-146
Fish Passage	3-146

Continued



Chapter 3

3.7.3.2	Alternatives Analysis	3-147
	Coarse Sediment.....	3-147
	Fine Sediment	3-150
	Hydrology	3-153
	Large Woody Debris.....	3-154
	Leaf and Needle Recruitment.....	3-160
	Floodplains and Off-channel Areas.....	3-160
	Water Temperature	3-161
	Forest Chemicals	3-163
	Fish Passage.....	3-164
3.7.3.3	Synthesis	3-168
	Puget Sound.....	3-170
	Olympic Coast	3-170
	Southwest.....	3-171
	Lower Columbia River	3-171
	Middle Columbia River	3-171
	Snake River.....	3-172
	Upper Columbia River downstream of Grand Coulee Dam	3-172
	Upper Columbia River upstream of Grand Coulee Dam.....	3-173

3.7.1 Introduction

Fish are an important natural resource that has both biological and economic significance in the State of Washington. In particular, Pacific salmon and trout are indicators of a properly functioning aquatic ecosystem because they require cool, clean water, complex channel structures and substrates, and low levels of silt (Bjornn and Reiser, 1991). In addition, Pacific salmon and trout have fostered economically important commercial and sport fishing industries. Many residents of the state consider the presence and ability to harvest salmon and trout an important component to a “northwest lifestyle” that makes Washington state a desirable place to live.

This section discusses the affected environment for selected species of salmon and trout in Washington and the expected environmental effects from implementing the Alternatives described in Chapter 2. The fish species selected as the focus of the discussion include chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*), and bull trout (*Salvelinus confluentus*). The rationale for selecting these species will be more fully explained in Chapter 3.7.2 (Affected Environment).

The Affected Environment section will also describe important components of the aquatic environment that Pacific salmon and trout require and that forest practices may have a significant effect. These components include water quality, water quantity, channel conditions, LWD, channel morphology, and fish passage. Many important factors that effect the sustainability of Pacific salmon and trout populations will not be discussed in detail or may not be mentioned because they are not influenced by forest practices.



The Effects Analysis (Chapter 3.7.3) relies heavily on discussions presented earlier in this document and within a number of appendices. These discussions and appendices are:

- Sediment (Section 3.2)
- Hydrology (Section 3.3)
- Water Quality (Section 3.6)
- Riparian Habitats (Section 3.4)
- Water Type Modeling (Appendix C)
- Riparian Analyses (Appendix D)
- Slope Stability Analysis (Appendix E)
- Forest Roads Evaluation (Appendix F)
- Watershed Analysis (Appendix H)
- Adaptive Management (Appendix I)
- Forest Chemicals (Appendix J).

In essence, the fish effects analysis in Section 3.7.3 synthesizes the appropriate components of the above analyses as they reflect upon the components of the aquatic environment described in the Affected Environment (Section 3.7.2) and the major issues developed during the scoping process. These issues are:

- Water quality
- Fish passage
- Fish habitat elements
- Channel conditions and dynamics
- Hydrology
- Watershed condition relative to roads.

A more complete discussion of the issues and the criteria used to evaluate the alternatives is provided in Section 3.0 (Environmental Effects).

3.7.2 Affected Environment

Below is a discussion of the affected environment for selected salmon and trout species on state and private lands within the state of Washington regulated by Forest Practices Rules. This discussion includes a short description of the species selected as indicators for the effects analysis and the rationale for their selection from all the fish species present in the state. The discussion also contains a review of their distribution and status within the 10 regions described in Chapter 2. Finally, this section contains a review of important components of the aquatic ecosystem upon which salmon and trout rely for sustaining healthy, well-dispersed populations.

More than 70 species of freshwater fish are present in the more than 30,000 miles of fish-bearing streams within Washington (Wydoski and Whitney, 1979). One or more fish species are often found in perennial streams with gradients less than 20 percent (Fransen et



Chapter 3

al., 1997). Occasionally, fish are found in streams with steeper gradients, but these circumstances are rare. Although fish may not be found in extremely steep streams, land-use practices can affect fish-bearing waters by transportation through the stream network. Consequently, the affected environment for fish includes both fish-bearing and nonfish-bearing streams.

SEPA requires that all significant effects must be addressed in an EIS. Two of the four goals of the Forest Practices Board for the Washington Statewide Salmon Recovery Strategy (FPB, 1999) have special reference to fish. One of the goals is to provide compliance with the ESA for aquatic and riparian-dependant species on all lands subject to the Forest Practices Act. A second goal is to restore and maintain riparian habitat on these forestlands to support a harvestable supply of fish. The analysis for fish will target fish species (“priority species”) that have commercial and/or sport harvest value, are candidate or listed species under ESA, and are known to be sensitive to forest practices.

Notably, NMFS has not listed any Pacific salmon or trout species as threatened or endangered throughout their entire range and many populations are considered healthy or at least stable. Rather, NMFS has listed salmon and trout based upon distinct populations that are “substantially reproductively isolated” and “represent an important component in the evolutionary legacy of the species” (Waples, 1991). NMFS has termed these populations “Evolutionarily Significant Units” or ESUs. In an analogous fashion, the USFWS has chosen to use the term “Distinct Population Segments” or DPSs for freshwater fish species under their regulatory authority.

Beginning in 1991 with the listing of Snake River sockeye salmon by NMFS, the ESA has increasingly affected the way government agencies and public and private landowners conduct business in or near the streams and rivers found in the state. The rate of new listings has escalated in recent years such that all of the Pacific salmon species, with the exception of pink salmon, have been listed as threatened or endangered within one or more areas of Washington (Table 3.7-1). In addition to the Pacific salmon and trout listed by NMFS, the FWS has listed bull trout throughout its range in the contiguous United States. Consequently, there are few areas within Washington State that do not have at least one listed fish species (Figures 3.7-1 through 3.7-3).

3.7.2.1 Life History of Priority Species

A basic understanding of the life history and habitat requirements of Pacific salmon and trout is important for recognizing the type and level of effects that may result from a land use activity such as timber harvest. The life history characteristics can vary significantly in different locations depending on climate, food supply, stream flow, and other factors (Flossi and Reynolds, 1994).

Chapter 3



Table 3.7-1. ESA-listed Anadromous and Candidate Freshwater Fish Species Found in Washington State

Species	Scientific Name	Population ^{1/}	ESA Status	Publication Date	Federal Register Citation
Chum Salmon	Oncorhynchus keta	Hood Canal Summer-run	Threatened	March 1999	64 FR 14508
		Columbia R.	Threatened	March 1999	
Coho Salmon	O. kisutch	Puget Sound—Straight of Georgia	Candidate	July 1995	60 FR 38011
		Lower Columbia River/SW Washington	Candidate	July 1995	
Sockeye Salmon	O. nerka	Snake R.	Endangered	November 1991	56 FR 58619
		Ozette Lake	Threatened	March 1999	64 FR 14528
Chinook Salmon	O. tshawytscha	Snake R.—Fall-run	Threatened	April 1992	57 FR 14653
		Snake R. Spring/Summer-run	Threatened	April 1992	
		Puget Sound	Threatened	March 1999	64 FR 14308
		Lower Columbia R.	Threatened	March 1999	
		Upper Willamette R.	Threatened	March 1999	
		Upper Columbia R. Spring-run	Endangered	March 1999	
Steelhead	O. mykiss	Upper Columbia R.	Endangered	August 1997	62 FR 43937
		Snake R.	Threatened	August 1997	
		Lower Columbia R.	Threatened	March 1998	63 FR 13347
		Upper Willamette	Threatened	March 1999	64 FR 14517
		Middle Columbia R.	Threatened	March 1999	
Sea-run Cutthroat Trout	O. clarki clarki	SW Washington/Columbia R.	Threatened	April 1999	64 FR 16397
		Puget Sound	Not Warranted	April 1999	64 FR 16397
		Olympic Peninsula	Not Warranted	April 1999	64 FR 16397
Bull Trout	Salvelinus confluentus	Columbia River	Threatened	June 1998	63 FR 31647
		Coastal - Puget Sound	Threatened	November 1999	64 FR 58909

^{1/} Populations of Pacific salmon are designated as Evolutionarily Significant Units by NMFS. The USFWS designates population segments as Distinct Population Segments.



Chapter 3

Figure 3.7-1. Distribution and ESA Status of Chinook and Chum Salmon within Washington State.

(Source: Streamnet Version 99.1; NMFS 1999.

Evolutionarily Significant Units GIS Data Layer.

<http://www.nwr.noaa.gov/1salmon/Salmesa/mapsuits.htm>)

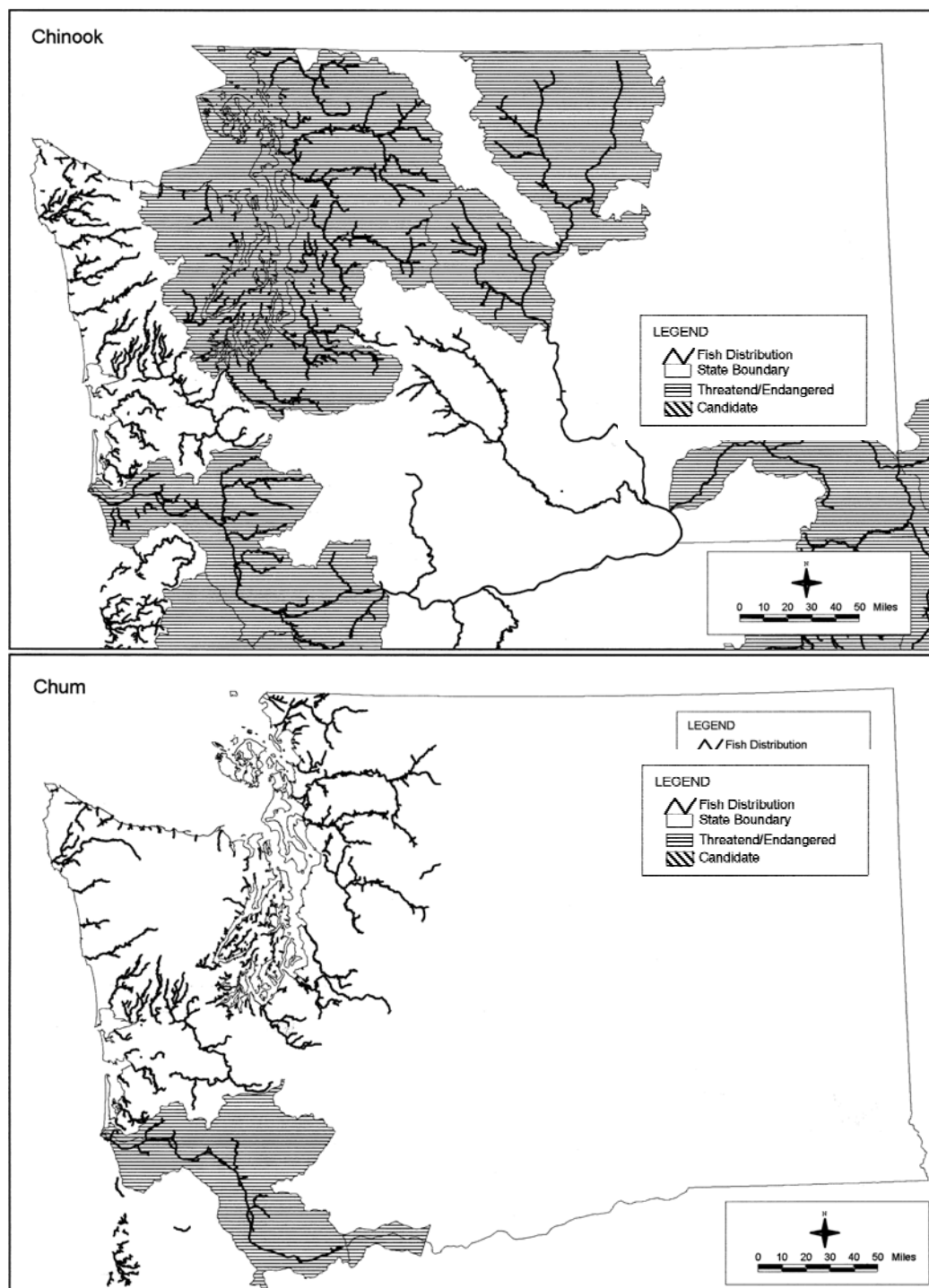
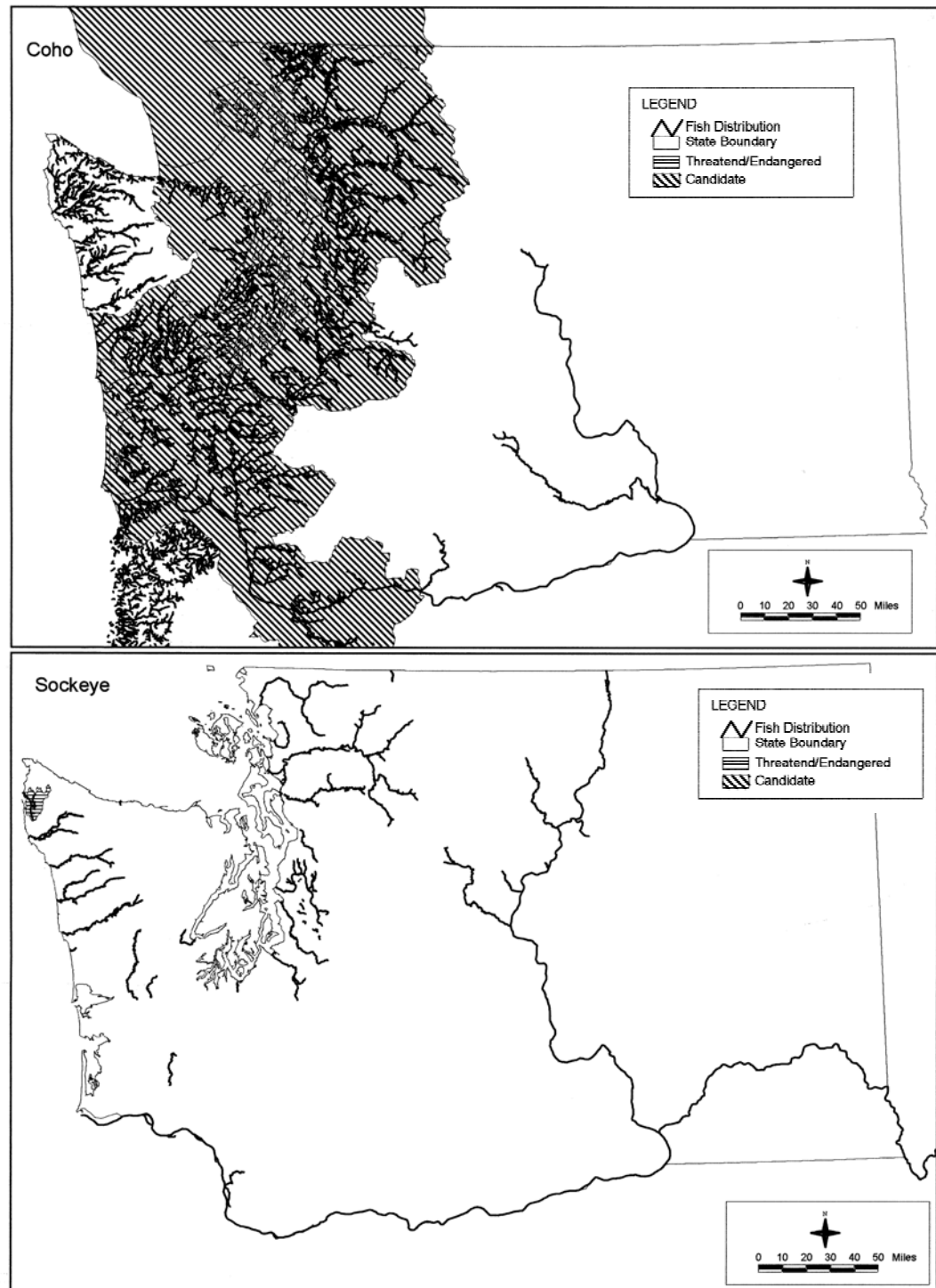




Figure 3.7-2. Distribution and ESA Status of Coho and Sockeye Salmon within Washington State.

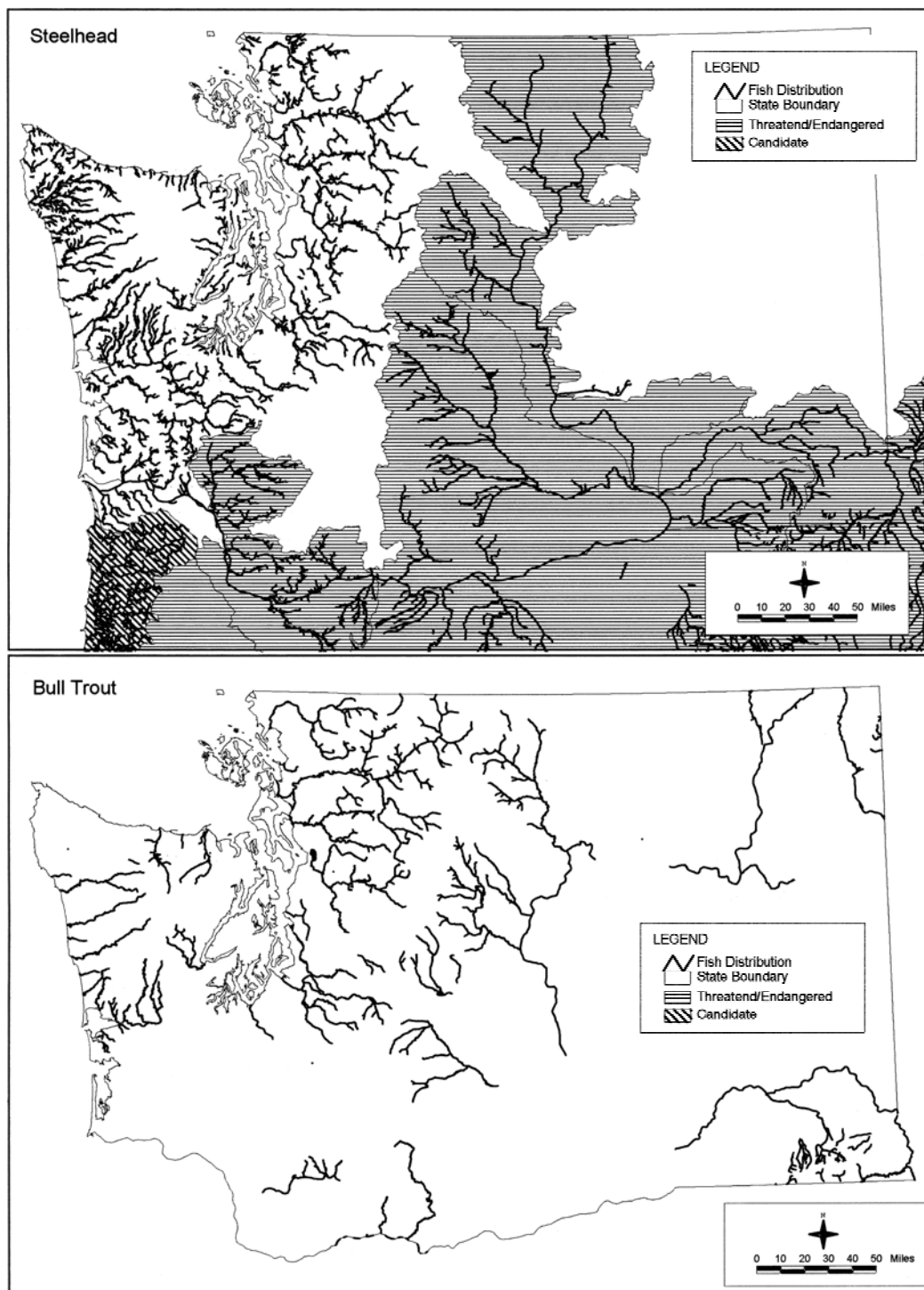
(Source: Streamnet Version 99.1; NMFS 1999. Evolutionarily Significant Units GIS Data Layer. <http://www.nwr.noaa.gov/1salmon/Salmesa/mapsuits.htm>)





Chapter 3

Figure 3.7-3. Distribution and ESA Status of Steelhead and Bull Trout (listed as Threatened throughout their Range) within Washington State.
(Source: Streamnet Version 99.1; NMFS 1999. Evolutionarily Significant Units GIS Data Layer. <http://www.nwr.noaa.gov/1salmon/Salmesa/mapsuits.htm> for Bull Trout-Washington DNR)





The life cycle of Pacific salmon and trout can be divided into seven distinct phases or lifestages: upstream migration, spawning, egg incubation, fry emergence, juvenile rearing, smolt outmigration, and marine rearing. Two important common denominators in the life history of Pacific salmon and trout is they all construct redds (nests) in gravel beds for spawning and they all include life history forms that exhibit anadromy. In other words, spawning occurs in freshwater, followed by migration to the ocean for feeding and maturation, and finally fish return to their natal sites for completion of the life cycle. Five of the species (*O. nerka*, *O. mykiss*, *O. clarki*, and *S. confluentus*) have life history forms that do not express the marine phase and live their entire lives in freshwater. The life cycle of Pacific salmon and trout can be considered a series of migrations operating at different spatial and temporal scales. The first migration occurs over a few centimeters of gravel that must be crossed by fry within a few hours while the final homing migration may span several thousands of kilometers and many weeks of travel. Within this relatively simple strategy of anadromy, several species demonstrate extremely complex variations in length of freshwater rearing, use of lake systems, run timing, degree of anadromy, and age structure. These variations, in conjunction with geographically separate spawning populations, have led to the stock concept of salmon management (Larkin, 1972). Indeed, it is the demonstration of unique behavioral patterns, physical characteristics, and ultimately genetic makeup that has made it possible to list any salmon stocks within the framework of the Endangered Species Act (Nehlsen et al., 1991; Waples, 1991).

One commonly recognized variation in life history traits for Pacific salmon and steelhead is run timing. The seasonal stock distinctions are based upon the date individual stocks of maturing adults enter freshwater. For example, chinook salmon are often divided into “spring,” “summer,” and “fall” runs while steelhead stocks are divided into “winter” and “summer” runs. Sockeye and chum salmon usually do not have multiple distinct runs and the seasonal descriptor is often omitted (but not always). Most pink and chum salmon in the Puget Sound Region enter freshwater during the fall while sockeye salmon runs peak in early July.

Additional stock and species-specific variability is demonstrated in the duration of freshwater rearing and the type of habitat that is utilized. Spring chinook salmon, coho salmon, and steelhead juveniles typically spend one or two years rearing in streams prior to outmigration. Similarly, sockeye salmon usually spend a year rearing in a lake prior to outmigration. In contrast, fall chinook and chum salmon outmigrate to the ocean as fry. Chum salmon usually complete their outmigration shortly after emergence (Wydoski and Whitney, 1979), while fall chinook may have a protracted outmigration period that occurs throughout the summer (Dawley et al., 1986). While most summer/fall chinook outmigrate during their first year, a small proportion overwinter in freshwater and then migrate as yearlings the following spring.

Bull trout and coastal cutthroat trout also express high variability in migratory behavior and habitat use. They have four different migratory forms: anadromous, adfluvial, fluvial, and resident. Adfluvial stocks rear in lake systems, but migrate to tributary streams for spawning. Fluvial stocks rear entirely in larger streams or rivers, but have significant



Chapter 3

migrations between headwater spawning and rearing areas. In contrast, resident stocks demonstrate little migratory behavior.

During the period of freshwater rearing, Pacific salmon and trout have life-stage and species-specific habitat requirements for spawning and rearing. Important components to spawning habitat include substrate size, water depth, and water velocity (Bjornn and Reiser, 1991). In general, the larger species utilize larger substrates and deeper and faster water (1.3-10.2 cm, >24 cm depth, 32-109 cm/s velocity; Bjornn and Reiser, 1991). Tail-outs to pools (the downstream end where the pool changes to a riffle) that meet criteria for these features are generally considered optimal spawning areas because stream morphology maximizes the passage of oxygenated water through redds. However, runs and riffles are also utilized during spawning. During spawning, females guard spawning territories and fight with other females for the best locations. In contrast, male salmon and trout fight with other males to earn the right to spawn with a female. Females dig redds by turning sideways to the stream bottom then rapidly flexing their tails. The digging results in a pit into which the eggs and milt are laid. The females dig a series of egg pits moving from downstream to upstream, consequently gravels removed during digging cover the eggs and pit downstream. Redd building is important for three principle reasons (Chapman, 1988): 1) redds provide physical protection to eggs during periods when they are extremely fragile; 2) redd digging removes a portion of the fines and sands deleterious to egg survival; and 3) redd construction and morphology enhances the passage of water through the egg pits.

Following emergence from the redd, salmon and trout fry typically utilize shallow and slow moving areas of a stream. Optimal depths and velocities increase as the fish grow, but preferred areas are usually associated with some form of cover, usually pools with LWD or boulders. Differences among the species are apparent in the degree of flexibility for utilizing riffles, runs, and other habitat features. Stream dwelling juvenile salmonids are typically territorial and exhibit a dominance hierarchy among individuals and species. Drifting insect larvae and benthic macroinvertebrates account for the majority of food items eaten by juvenile salmon and trout within streams. In contrast to the typical stream dweller, sockeye fry migrate to a lake shortly after emergence where shallow nearshore (or littoral) areas are preferred habitat. As sockeye fry grow, they begin to move offshore and have a characteristic diurnal vertical migration timed for utilization of zooplankton food sources.

Riparian areas have distinctive resource values and characteristics that are critical to salmonid production. Riparian vegetation is important for maintaining streambank and floodplain integrity. The vegetation slows water velocity on the floodplain and roots inhibit erosion along stream and riverbanks, which reduces sediment deposition in streams. Riparian vegetation also helps to provide shade, leaf and needle litter important to aquatic food chains, and LWD. Clearing or harvesting trees near streambanks removes riparian vegetation and can affect sediment delivery, fish habitat and reproduction, and stream productivity.



In general, the marine phase of salmonid life history is not understood as well as the freshwater phase. Only recently have ocean environmental conditions been considered an important factor in the management of salmon resources (Bisbal and McConnaha, 1999). Historically, the ocean was assumed an unlimited resource for salmon production, but this assumption is now being widely questioned. Forest practices have little to no direct effect on this important lifestage of anadromous salmonids.

The following sections provide a life history for each of the priority species considered in this EIS.

Chinook Salmon

Chinook salmon are the largest of the salmon with weights sometimes exceeding 88 pounds. Their size makes them one of the most valuable of the salmon, giving them the moniker “King” salmon. They also have one of the most complicated life history patterns. Their large size results in part from their relatively long lives. Chinook salmon may live up to 8 years, although most stocks return predominately as 3, 4, or 5-year olds to spawn in larger streams and rivers. A small, but significant portion of most chinook stocks returns precociously after spending 1 year in the ocean. These individuals are usually males and commonly called “jacks.” Some immature chinook salmon (sometimes referred to as “blackmouth”) from the Puget Sound region remain within the sound throughout their marine rearing phase. Most chinook from Washington State rear along the continental shelves bordering Washington, British Columbia and Southeastern Alaska.

As discussed earlier, chinook salmon are referred to as spring, summer, or fall stocks depending upon the time of return to freshwater. However, all chinook salmon spawn in the late summer or early fall. Freshwater rearing strategies are often different among the three stock types. Spring chinook salmon are often called “river-type” while summer and fall stocks may be called “ocean-type.” River-type stocks usually spend an entire year in freshwater prior to smoltification and out-migration. In contrast, ocean-type stocks begin to migrate to the ocean during their first year of life.

Coho Salmon

Coho salmon are medium-sized, reaching weights up to 10 pounds or more, but more commonly weighing 4 to 7 pounds. Coho salmon are also commonly known as silver salmon. Coho salmon primarily spawn at age 3 (never 4), but also have a small proportion that return precociously as 2-year-old jacks. Coho salmon usually spend their first year rearing in rivers and streams prior to smoltification and outmigration. During their marine phase, coho salmon from the Pacific Northwest rear primarily on the continental shelf off Washington and British Columbia.

Sockeye Salmon

Sockeye salmon are a medium-sized fish averaging about 5 to 6 pounds. They are also known as red salmon because of their firm red flesh, and the red spawning colors that become apparent after maturing adults enter fresh water. Sockeye salmon are unique among the Pacific salmon for requiring lakes during their freshwater rearing phase. Most sockeye salmon undergo smoltification during their second year and migrate to the ocean.



Chapter 3

Most sockeye salmon return to spawn after 2 or 3 years of rearing in the ocean, but a small proportion return as jacks. Two sockeye salmon populations have been listed by NMFS under the Endangered Species Act. Snake River sockeye have been listed as endangered, and the Ozette Lake population on the Olympic Peninsula have been listed as threatened. The Snake River population spawn in Idaho. Consequently, Washington State is primarily concerned with maintaining properly functioning migratory habitat for this population.

Chum Salmon

Chum salmon are relatively large, reaching an average size of nine pounds after spending 4 or more years rearing during their marine phase (Wydoski and Whitney, 1979). Chum salmon are commonly called dog salmon because Native Americans often utilized this species to feed sled dogs in Alaska and Canada. Chum salmon fry migrate to estuarine and marine waters shortly after emergence and migrate long distances. One tagged individual was known to migrate over 3,000 miles within 6 months (Scott and Crossman, 1973). Spawning areas utilized by chum salmon are usually in the lower reaches of larger river and streams.

Steelhead

Steelhead trout have a freshwater rearing period of 1 to 3 years before smoltification and outmigration while the alternative form, rainbow trout, spend their entire lives in freshwater. The marine phase for steelhead lasts an additional 2 to 4 years. Most steelhead are 4 years old when they return to their natal stream for spawning and weigh between 5 and 10 pounds (Wydoski and Whitney, 1979). Steelhead may spawn more than once. However, fewer than 15 percent of a spawning population are usually repeat spawners. Rainbow trout are usually much smaller than their anadromous counterpart, but under some conditions can reach lengths of 20 inches or more. In general, rainbow trout do not appear to be at the same level of risk as steelhead and other species in the family. However, some subspecies, such as redband trout (*O. mykiss gairdneri*) which are found in some areas east of the Cascade Crest are a species of concern on lands managed by the Forest Service.

Coastal Cutthroat Trout

The West Coast sea-run cutthroat trout is currently listed as threatened in the southwest Washington and Columbia River DPSs. The coastal sea-run cutthroat trout is 1 of 13 subspecies of cutthroat trout indigenous to North America. Of the 13 subspecies, only the coastal sea-run cutthroat trout is anadromous. Throughout its range, the coastal cutthroat trout also exhibits a stream resident form and adfluvial form.

The life history of the coastal cutthroat is one of the most complex and flexible of any Pacific salmonid (Wydoski and Whitney, 1979; Johnson et al., 1994). Cutthroat trout in the region exhibit resident, fluvial, adfluvial, and anadromous life histories. Little is known about the life histories and the relative proportion of each life history in this population. Coastal cutthroat trout spawn in the smallest headwater streams and tributaries used by any salmonid species, and the young usually remain in these streams about a year before moving down into larger streams (Palmisano et al., 1993). They live in these larger



streams for another 2 to 5 years (usually 3) before migrating to the Pacific Ocean (Wydoski and Whitney, 1979; Johnson et al., 1994). Some stocks, primarily those with limited or no possibility of return migration from the ocean, remain as residents of small headwater tributaries, or migrate only into rivers or lakes (Scott and Crossman, 1973; Johnson et al., 1994). Sea-run cutthroats do not migrate to the open ocean; rather, they stay in estuarine habitats near the mouths of their natal streams for 5 to 8 months of the year (Palmisano et al., 1993; Johnson et al., 1994). Upstream migration to freshwater feeding/spawning areas occurs from late June through March; re-entry timing is consistent from year to year within streams, but varies widely between streams (Johnson et al., 1994). Spawning generally occurs between December and May in the tails of pools located in streams with low gradient and low flows or in shallow riffles (Wydoski and Whitney, 1979; Johnson et al., 1994).

Bull Trout

Bull trout in the Puget Sound Region and Columbia River are currently listed as a threatened species by USFWS under ESA. Historically, bull trout and its conspecific, Dolly Varden trout, were considered the same species. The names were commonly used to distinguish anadromous coastal stocks from resident stocks. During the early 1990s, genetic and meristic (counts of physical characters) analyses demonstrated that the species were distinct from each other. From a practical aspect, however, the two species are indistinguishable in the field, even for experienced professional fisheries biologists. Furthermore, life history traits and habitat requirements appear to overlap considerably between the two species.

Similar to cutthroat trout, bull trout have a flexible life history that includes resident, fluvial, adfluvial, and anadromous forms. Bull trout populations in the Columbia River system generally do not exhibit anadromy. Anadromous bull trout, which are found in the Puget Sound Region and coastal regions, initially rear in freshwater for 2 to 3 years. Large oceanic migrations do not occur. Instead, anadromous bull trout migrate to estuarine and nearshore areas in the spring then migrate up-river during the fall to over-winter in freshwater.

Bull trout appear to be one of the more sensitive salmonids to degraded habitat conditions, primarily due to having fairly restrictive requirements. In freshwater, adult bull trout prefer very cool water temperatures for rearing (less than 55°F) and spawning (less than 50°F; Oregon DEQ, 1995). In addition, this species prefers a stream morphology that is complex, including large amounts of LWD and boulders, which contribute to large, deep pools with complicated water velocity patterns and cover. Bull trout and Dolly Varden trout also appear to be more sensitive to the effects of fines on the survival of incubating eggs than other salmonids.

3.7.2.2 The Aquatic Ecosystem

Key physical components of the aquatic ecosystem include channel morphology (floodplains, streambanks, channel structure), water quality, and water quantity. Habitat complexity is created and maintained by rocks, sediment, large wood, and favorable water quantity and quality. Upland and riparian areas influence aquatic ecosystems by supplying



Chapter 3

sediment, woody debris, and water. Disturbance processes such as landslides and floods are important mechanisms for delivery of wood and bedload to streams.

Natural channels are complex and contain a mixture of habitats differing in depth, velocity, and cover (Bisson et al., 1987). They are formed during storm events that have associated flows which mobilize sediment in the channel bed (Murphy, 1995). The hydrologic regime of a watershed, combined with its geology, hillslope characteristics, and riparian vegetation determines the nature of stream channel morphology (e.g., number and spacing of pools and width-to-depth ratio) (Beschta et al., 1995; Sullivan et al., 1987). Therefore, activities in these areas would be expected to affect the shape and form of the stream channel. For example, substantial increases in volume and frequency of peak flows can cause streambed scour and bank erosion. A large sediment supply may cause aggradation (i.e., filling and raising the streambed level by sediment deposition) and widening of the stream channel, pool filling, and a reduction in gravel quality (Madej, 1982). Upslope activities (e.g., timber harvest, land clearing, and road development) can change channel morphology by altering the amount of sediment or water contributed to the streams. This, in turn, can disrupt the balance of sediment input and removal in a stream (Sullivan et al., 1987).

Stream habitat conditions in Washington are affected by a wide range of factors including geophysical changes (e.g., volcanic eruptions, earthquakes and associated uplifting), extremes of flow (e.g., flooding and low flow), existing geological conditions (e.g., erodible soils), and land-use practices (e.g., timber harvest, grazing, urban development, road construction and operation, and gravel mining). The effects of these combined factors result in the existing stream habitat conditions.

Streams that lack a balance between pools and riffles are often less productive than streams that have more complex structure. Pools are used as holding and resting areas for adult fish prior to spawning, deep water cover for protection, and cool water refugia during low flow summer months. Riffles are important for reoxygenation of water, habitat for food organisms such as aquatic macroinvertebrates, and as rearing areas for fish (Gregory and Bisson, 1997). Intensive timber harvest has been reported to decrease pool depth, surface area, and the general diversity of pool character (Ralph et al., 1994). Possible mechanisms include decreased occurrence of LWD (which can help form and stabilize pools) and filling of remaining pools with bed material.

A range of optimum pool-to-riffle ratios for a properly functioning system has been described in the literature (NMFS, 1996; FWS, 1998). Applying any values within this range to field conditions would require considering site-specific characteristics such as existing LWD, stream gradient, bank characteristics, sediment load, bed material (e.g., bedrock and boulders), and other watershed factors such as hydrologic conditions (Murphy, 1995).

The following describes components to the aquatic ecosystem that are influenced by forest practices. These include coarse sediment, fine sediment, hydrology, LWD, leaf/needle litter recruitment, floodplains and off-channel features, water temperature, forest chemicals (contaminants), and fish passage.



Coarse Sediment

A certain amount of bedload material is necessary to provide substrate for cover and spawning habitat for fish. For example, anadromous salmon typically use gravels ranging from 0.5 to 4 inches (12.7 to 101.6 mm), whereas steelhead and resident trout may use smaller substrates ranging from 0.25 to 4 inches (6.4 to 101.6 mm; Bjornn and Reiser, 1991). Increased levels of coarse sediment bedload above background levels can, however, lead to stream bank instability, pool filling, and changes in the water transport capacity of the channel (Spence et al., 1996). The larger the sediment size, the higher the flow that is required to mobilize the sediment. Consequently, the recovery periods for streams with severe coarse sediment aggradation could range from decades to 100 years or more. The major factors influencing the excessive delivery of sediment to a stream include the intensity and location of stream bank erosion, mass-wasting events, and road and culvert failures.

Fine Sediment

Adequate dissolved oxygen (DO) levels are important for supporting fish, invertebrates, and other aquatic life. Salmonids are particularly sensitive to reduced DO (DEQ, 1995). Intergravel DO has been recognized as crucial to the survival of salmonid embryos. Intergravel DO depends on several interrelated factors such as water temperature, surface-water concentrations, percentage of fine sediment and gravel in pores, and the oxygen demand of the eggs. Management-induced depletion of DO in stream water can occur from harvest activities, such as excessive amounts of logging debris left in a stream that can result in decreased DO (MacDonald et al., 1991). Critical levels of DO also depend on the velocity of the water passing the eggs, as less oxygen is needed at higher velocities (DEQ, 1995). Forest management activities can exacerbate any intergravel DO problems through increases in fine sediment which reduce intergravel water velocity (Bjornn and Reiser, 1991; Ringler and Hall, 1975; Moring, 1975).

Fine sediment (0.004 to 0.033 inch or 0.1 to 0.84 mm in diameter) can reduce stream habitat quality, restrict sunlight penetration, and fill pores between the gravel, thus preventing the flow of oxygen-rich water to fish eggs that may be deposited in the gravel. In laboratory studies, a substrate containing 20 percent fines was found to reduce emergence success of young salmon and trout by 30 to 40 percent (Phillips et al., 1975; MacDonald et al., 1991). According to study results and summaries from Peterson et al. (1992) and Chapman (1988), a properly functioning aquatic habitat would have substrates that contain less than 11 to 16 percent particles within the fine sediment category.

Fine sediments and larger particles (up to about 0.27 inch [6.84 mm] or sand-sized fractions) can also smother fish eggs and developing young in the gravel. In addition, they may also clog pores or breathing surfaces of aquatic insects, physically smother them, or decrease available habitat (Spence et al., 1996; Nuttall and Bielby, 1973; Bjornn et al., 1974; Cederholm et al., 1978; Rand and Petrocelli, 1985). Important factors influencing the excessive delivery of fine sediment to a stream include the presence of adequate streamside vegetation to filter fine sediment derived from hillslopes and road surface



Chapter 3

erosion (see Sections 3.2 and 3.5). Also, fine sediment is usually present with coarse sediment delivery processes described above.

Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al., 1987). Turbidity can also interfere with feeding behavior or cause gill damage in fish (Hicks et al., 1991), but may provide some positive benefits. For example, it can provide cover from predators (Gregory and Levings, 1998).

Hydrology

The amount of water provided to aquatic ecosystems at critical times is important for sustaining fish and other aquatic species. Many fish have become adapted to natural flow cycles for feeding, spawning, migration, and survival needs. The timing, magnitude, and duration of peak and low flows must be sufficient to create and maintain riparian and aquatic habitat. Flows can be influenced by management activities such as timber harvest and roads (see Section 3.3). In general, low- or base-level stream flows that occur during the late summer often limit habitat for rearing juvenile salmon and trout. They can also negatively affect migration and access to habitat and food resources, as well as disrupting spawning behavior. Such conditions can occur naturally during this period due to lack of precipitation. However, low flows can be exacerbated by water withdrawals, silting (which can decrease pool depth), and stream widening resulting from unstable banks.

High winter flows and floods that scour the streambed can be detrimental to eggs or young fish that may be incubating in the stream gravels. Both extreme high and low flow conditions may occur in different regions of the state. Rain-on-snow events are a common reason for flooding and streambed scour on the west of the Cascade Mountains. In contrast, the eastern side of the state lies in the rainshadow of the Cascade Mountains. Consequently, extreme low flows and high water temperatures can be detrimental during the summertime.

Large Woody Debris

LWD includes trees and tree pieces greater than 4 inches in diameter and 6 feet long (Keller and Swanson, 1979; Bilby and Ward, 1989). LWD is one of the most important components of high quality fish habitat (Marcus et al., 1990). LWD provides food and building materials for many aquatic life forms and is important for stream nutrient cycling, macroinvertebrate productivity, and cover for juvenile and adult fish (Marcus et al., 1990). LWD is the primary channel-forming element in some channel types and affects many aspects of channel morphology including stream roughness, sediment storage, water retention, energy dissipation, and fish habitat (Marcus et al., 1990; Lisle, 1986; Swanson et al., 1987; Martin, et al., 1998). Pools formed by stable accumulations of LWD provide important habitat for rearing salmonids, particularly in winter (Heifetz et al., 1986; Murphy et al., 1986). The value of LWD in providing aquatic habitat depends on stream size, tree species, and numerous other factors (see Section 3.5).



Field studies in old-growth, Douglas-fir forest streams in coastal Oregon and Washington have shown that the number of woody debris pieces varies by channel width and size of debris under undisturbed conditions. For example, studies by Bilby and Ward (1989) and Forest Practices Board (1995) show that the number of LWD pieces decreased with increasing width of a stream; however, the average diameter, length, and volume of LWD increased. The type of wood is an important factor (see the Riparian Function Section). For example, coniferous wood (e.g., Douglas-fir or cedar) is more resistant to decay than deciduous wood (e.g., alder). Therefore, coniferous wood has a greater longevity in a stream (Cummins et al., 1994, as quoted in Spence et al., 1996).

Historical forest management practices often included splash dams and stream cleaning efforts (Maser and Sedell, 1994). During the last century, splash dams were built to aid in floating and transporting harvested trees to the mill. From the 1950s through the 1970s, removal of LWD from streams was based on the belief that it was detrimental to salmon migration. Both of these practices contributed to major changes in the amount of cover habitat available and often changed stream habitats to a single, cobble-bed channel lacking pools and LWD or to bedrock channels lacking gravel, woody debris, and other channel features (Murphy, 1995; Maser and Sedell, 1994). This decrease in LWD corresponds to a reduction in salmonid use (House and Boehne, 1987). Due to the time required for streamside trees to grow and mature to potential LWD, there may be a considerable lag period (e.g., greater than about 50 years and up to 300 years) before additional LWD is contributed to a cleared stream (Gregory and Bisson, 1997).

In general, information on LWD must be viewed from the perspective of the timber harvest activity in the area, historic floods that have removed or redistributed LWD, and the activities that were performed to actively remove LWD (see the Riparian Function Section). Potential LWD recruitment from existing mature or old-growth riparian zones would be anticipated to be higher than younger or recently clearcut areas (see the Riparian Function Section). There may be no potential for LWD recruitment in currently open areas such as prairies and grasslands, which may not develop into forested areas in the foreseeable future.

LWD enhancement has become a more common method for improving stream reaches lacking wood. The methods for placing LWD are fairly advanced (ODF and ODFW 1995). LWD placement would provide short-term benefits to stream systems providing a more complex habitat structure, nutrient input, and substrate for invertebrate colonization, all of which would benefit fish habitat. These benefits may improve current conditions in many areas until the natural riparian corridor can regenerate and provide consistent inputs of LWD.

The Aquatic Food Chain

The base of the aquatic food chain is derived from the combination of dissolved chemical nutrients and detrital materials. The chemical constituents such as nitrogen (usually in the form of nitrates and nitrites), phosphorus, and carbon can be derived from the breakdown of detritus and through leaching and runoff from surrounding soils (Gregory et al., 1987). Many bacterial and macroinvertebrate species rely directly on detrital material from leaf



Chapter 3

and needle litter, branches, and stems from the surrounding riparian zone vegetation. Some estimates indicate that leaf and needle recruitment may provide up to 60 percent of the total energy input to stream communities (Richardson, 1992). Other macroinvertebrate species rely on aquatic algae that primarily use dissolved chemical nutrients and require solar radiation. In streams containing spawning habitat for Pacific salmon, significant influxes of nutrients from the marine environment occur during the decomposition of carcasses (Bilby et al., 1996).

The abundance and diversity of macroinvertebrate food sources to salmonids is dependent upon the primary algae and detrital food sources. Forest harvest activities affect the food chain by changing the relative macroinvertebrate production between herbivores and detritivores (Gregory et al., 1987). The magnitude and duration of the change is dependent upon a variety of factors including stream size, gradient, location (headwater versus mainstem) and the type of riparian vegetation and management prescriptions. Gregory et al. (1987) suggest that tree harvest in riparian areas initially lead to higher production of fewer invertebrate species and that recovery of the macroinvertebrate community occurs over periods similar to recovery of riparian zones. Bilby and Bisson (1992) observed higher summer production of coho fry in streams in a watershed with extensive clearcuts relative to a nearby, undisturbed watershed with an old-growth riparian stand. However, no differences in coho production were present during fall censuses and the higher summer fish production was attributed to higher algae production (Bilby and Bisson (1992). Bilby and Bisson (1992) and Spence et al. (1996) have noted that other changes in habitat features (e.g., numbers of pools) required by yearling and adult fish could likely offset any increases in sub-yearling production. Gregory et al. (1987) argued that short-term higher fish productivity might occur downstream of timber harvest units in some areas, but at the expense of long-term stability in the overall abundance and diversity of the aquatic community.

Floodplains and Off-channel Habitat

Floodplains and off-channel areas are an important component of aquatic habitat that include side channels, backwater alcoves, ponds, and wetlands. They provide important habitat seasonally to particular life stages as well as input of organic matter and LWD. Seasonally flooded channels and ponds are particularly important for rearing coho salmon and other fish species during winter months. Large floodplains can also function as filters for subsurface flows and maintenance of water quality (Gregory and Bisson, 1997). Some backwater alcoves and ponds result from groundwater seeps and may have shade levels higher than the main channel. These areas provide cool water refugia during high summertime temperatures. Major floodplains in the planning area generally are located in the lowest reaches of major rivers. Beavers can play a significant role in the development of ponds and wetlands important as habitat for salmon and trout, particularly for juvenile coho salmon (Cederholm et al., 2001).



Water Temperature

Water temperature plays an integral role in the biological productivity of streams. Water temperature fluctuations and their relationship to DO can affect all aspects of salmon and trout life histories in fresh water including

- incubation and egg survival in stream gravel;
- emergence, feeding, and growth of fry and juvenile fish;
- outmigration of young fish;
- adult migration, holding and resting; and
- prespawning and spawning activities.

A rise in temperature increases the metabolic rate of aquatic species. Consequently, more energy is required, even during periods of low activity. In addition, DO decreases as water temperature increases, potentially increasing stress on fish. Water temperatures in the range of 70°F (about 21°C) or greater can cause death in cold-water species such as salmon and trout within hours or days (Oregon DEQ, 1995). In general, water temperatures of 53.2 to 58.2°F (11.8 to 14.6°C) have been found to provide a properly functioning condition for juvenile salmon and trout. However, bull trout require much lower temperatures during spawning (4-10°C) and egg incubation (1-6°C) (Oregon DEQ 1995).

Increases in water temperature in forest streams can often be traced to reduction of shade-producing riparian vegetation along fish-bearing and tributary streams that supply water to other fish-bearing streams. However, streams also naturally tend to become warmer as water flows from headwaters to the sea (Sullivan et al. 1990, Zwieniecki and Newton 1999). This warming occurs as water equilibrates to local environmental conditions including air temperature, which in turn is highly correlated with elevation. In addition, water temperatures can be affected by stream widening, sedimentation/stream depth, microclimate, groundwater, and other upstream inputs (see Section 3.6). Long-term sublethal temperature effects can be detrimental to the overall health of a population as well as short-term acute effects of warmwater temperatures on cold-water aquatic species. Heat stress may accumulate such that increased exposure for juvenile fish in an environment in which growth is reduced or the inability to meet increased metabolic (energy) demands increases their susceptibility to disease (Oregon DEQ, 1995).

More shade or complete shading does not always maximize aquatic productivity. The availability of instream algae can be a limiting factor in some streams. Algae and other sources of vegetable matter are at the lowest level of the food chain and important to higher trophic level production such as fish. Nutrients (e.g., nitrogen and phosphorus) are key factors along with light that result in algae production. High levels of shade can result in low levels of algae production even if adequate nutrient sources are present (Gregory et al., 1984). Under unmanaged conditions, forested lands generally have low light and low primary productivity in low order streams with high canopy cover. In contrast, primary productivity in wide high order streams is generally unaffected by riparian management because adequate light penetration occurs even under mature riparian conditions (Gregory et al., 1984).



Chapter 3

Forest Chemicals

Water quality contaminants (e.g., petroleum products, chemicals, sewage, and heavy metals) can severely impair aquatic ecosystems either by sublethal (e.g., reduced growth) or lethal effects (e.g., fish kills). The water quality contaminants considered here are pesticides used to prevent tree diseases and deter pest plant species that compete with trees for nutrients, space, and light.

Fish Passage

Upstream migration of adult salmon, steelhead, and trout to spawning areas or redistribution of rearing fish to potential habitat in upstream areas can be impeded or blocked by a number of different mechanisms. These mechanisms can include the following:

- **Water Temperature**—Elevated water temperatures (e.g., greater than 68°F [20°C] or 60°F [15.6°C] for fall chinook salmon and coho salmon, respectively) are known to stop the migration of fish (Bjornn and Reiser, 1979).
- **DO**—At least 5 mg/l of DO is recommended to provide oxygen needs for migrating fish (Bjornn and Reiser, 1979). Decreased oxygen can occur as a result of high water temperatures and oxygen consumption created by decay of organic debris, chemicals, and respiration.
- **Turbidity**—High levels of sediment (e.g., 4,000 mg/l) have been reported (Bjornn and Reiser, 1979) as ceasing upstream migration.
- **Physical Barriers**—High waterfalls or cascades that are beyond the jumping or physical capabilities of fish, can prevent upstream migration. Similarly, excessive water velocities that result in conditions that are beyond the physical capabilities of a given fish species can also restrict or prevent upstream migration. The maximum velocity beyond which coho and chinook salmon cannot successfully move upstream is about 8 feet per second (2.44 meters per second) (Bjornn and Reiser, 1979).
- **Man-made Barriers**—Man-made barriers include features such as dams and stream crossings (usually culverts, but sometimes bridges as well).

Stream crossings by forest roads are the most common passage barrier influenced by Forest Practices Rules. A hydraulic project approval (HPA) is needed for the construction of stream crossings which are regulated by WDFW under the Hydraulic Code (WAC 220-110-070). Shallow water depths from conditions such as low flow can impede or prevent passage (e.g., upstream migration of chinook or coho salmon is not generally successful at depths less than about 0.8 foot (0.24 meter) or 0.6 foot (0.18 meter), respectively (Bjornn and Reiser, 1979). Such conditions can occur during low flow periods where riffles between pools can become completely dry or lack sufficient depth for passage. Barriers such as culverts used at stream crossings can prevent passage due to high water velocities, restricted depths, excessive elevation for successful entry, size and length, and other factors. Similarly, debris jams can prevent or delay upstream passage (Bjornn and Reiser, 1979).



3.7.2.3 Regions of the State

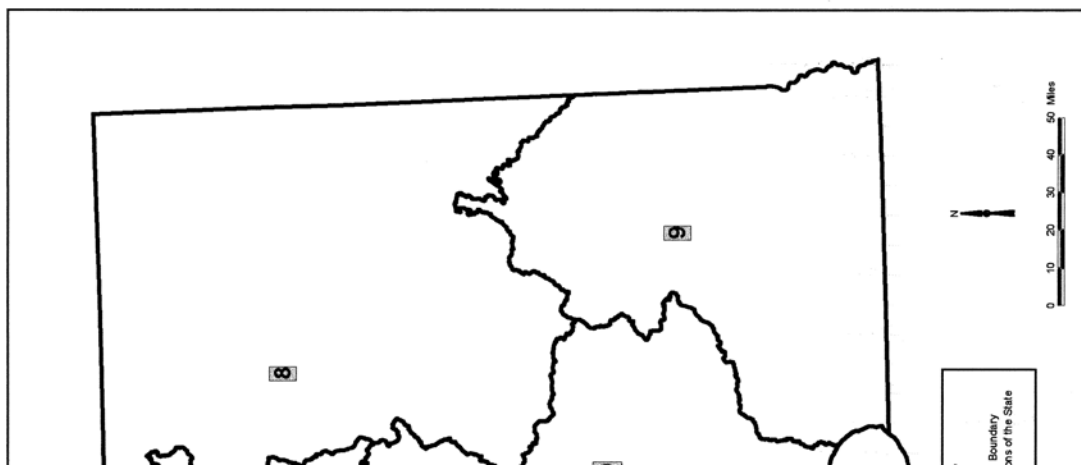
For the purposes of this analysis, the state has been divided into the following ten regions. These regions are mapped in Figure 3.7-4.

- Puget Sound;
- Islands;
- Olympic Coast;
- Southwest;
- Lower Columbia;
- Mid-Columbia;
- Columbia Basin;
- Upper Columbia below Grand Coulee Dam;
- Upper Columbia above Grand Coulee Dam; and
- Snake River.

The distribution of the priority species and state or commercial forestlands is very different within each of the regions. In addition, the number and type of factors that influence the current conditions of the aquatic system and status of the priority species in each of the regions are very different. NMFS sometimes refers to general factors affecting listed salmonid species as “the 4-Hs.” These are habitat, hatcheries, hydropower, and harvest. Forest Practices Rules are generally considered to affect only the habitat part of the complex issues. In addition, other land-use practices such as agriculture and urbanization can also have a significant effect on habitat.

Two of the regions, Islands and the Columbia Basin, will not weigh heavily in the analysis for fisheries because only a relatively small number of streams exist in forested portions of these regions or they contain low numbers of priority species. The following is a short synopsis of the remaining eight regions in regards to the priority species present and the components of the 4-Hs affecting their ESA status. Tables 3.7-2 and 3.7-3 show the distribution of fish-bearing and nonfish-bearing streams among different forest ownership and non-forested categories. The relative distribution of fish and nonfish-bearing streams can be important from the perspective of sediment production and delivery. High gradient, nonfish-bearing streams are generally source and transport reaches for sediment and low

Figure 3.7-4. Ten Regions of Washington Used for Analysis in this EIS





Chapter 3

Table 3.7-2. Estimated Distribution of Fish-bearing^{1/} Stream Miles among Forested Ownership and Nonforested Categories in Washington State

Region	Percent of Fish-bearing Stream miles within Region					Total Fish-bearing Stream Miles
	Private Forested	State Forested	Federal Forested	Other ^{2/} Forested	Non-Forested	
Puget Sound	43.0	8.7	8.7	4.3	34.7	9,843
Islands	29.9	2.6	1.3	0.0	66.2	444
Olympic Coast	40.9	22.7	9.1	9.1	18.2	2,831
Southwest	71.4	9.5	0.0	0.0	19.0	5,420
Lower Columbia	61.5	7.6	7.6	0.0	23.0	3,524
Middle Columbia	36.4	9.1	18.2	9.1	27.3	1,874
Snake	33.0	0.0	16.7	0.0	50.0	342
Columbia Basin	0.0	0.0	0.0	0.0	100.0	10
Upper Columbia Downstream of Grand Coulee	20.0	0.0	20	0.0	60.0	1,316
Upper Columbia Upstream of Grand Coulee	30.8	0.0	15.4	15.4	38.5	3,694

^{1/} Stream Types 1 to 3.

^{2/} Other includes city, county, tribal, and unknown ownership.

Table 3.7-3. Estimated Distribution of Nonfish-bearing^{1/} Stream Miles among Forested Ownership and Nonforested Categories in Washington State

Region	Percent of Nonfish-bearing Stream miles within Region					Total Nonfish-bearing Stream Miles
	Private Forested	State Forested	Federal Forested	Other ^{2/} Forested	Non-Forested	
Puget Sound	36.4	11.7	40.3	2.6	10.3	32,953
Islands	73.9	4.3	0.0	0.0	17.4	133
Olympic Coast	25.6	23.0	38.5	10.2	2.6	10,038
Southwest	79.7	11.4	3.8	0.0	3.8	20,390
Lower Columbia	56.3	11.4	27.6	0.0	3.4	23,584
Middle Columbia	30.3	11.2	36.0	13.5	10.1	15,162
Snake	20.2	2.1	42.6	0.0	33.0	5,355
Columbia Basin	0.0	0.0	0.0	0.0	0.0	0
Upper Columbia Downstream of Grand Coulee	16.8	7.4	64.2	4.2	6.3	25,008
Upper Columbia Upstream of Grand Coulee	32.1	5.7	28.7	25.3	8.0	24,718

^{1/} Stream Types 4, 5, and 9 (westside only).

^{2/} Other includes city, county, tribal, and unknown ownership.



gradient, fish-bearing streams are areas of sediment accumulation. The information provides some insights on which regions might be most affected by changes in FPRs. It also provides an indication of the type of management approach might be prevalent on fish versus nonfish-bearing waters of the state. For example, in regions on the west side (Puget Sound, Olympic Coast, Southwest, and Lower Columbia) streams within federal Ownership are managed based upon the Aquatic Conservation Strategy outlined in the Northwest Forest Plan. The tables (3.7-2 and 3.7-3) suggest that federal management on the west side has a larger influence on nonfish-bearing streams than fish-bearing streams. They also suggest that forest practices rules on private forested lands have a relatively large influence on management strategies along fish-bearing streams.

Puget Sound

This region includes all of Puget Sound south of the Canadian border, exclusive of the San Juan Islands (the Islands Region). This region also includes rivers and streams along the Straights of Juan de Fuca from Puget Sound to the Elwha River (inclusive). Puget Sound has the lowest overall stream density of the westside regions with a density of 3.2 mi/mi². All of the priority species are present in the Puget Sound Region (Figures 1 to 3). Chinook, and bull trout are listed as threatened in the region plus a summer run of chum salmon that are found in the Hood Canal portion of the region. Coho salmon is a candidate species. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations). Notably, the two major hydroelectric dams on the Elwha River have blocked large portions of spawning habitat from access and are under consideration for breaching. Many of the lowland areas of the region are highly urbanized. This region is the most heavily populated region of the state. About 52 percent of the fish-bearing and 48 percent of the nonfish-bearing streams occur on private and state forestlands (Tables 3.7-2 and 3.7-3). In contrast, Federal management strategies occur on about 9 percent of the fish-bearing and 40 percent of the nonfish-bearing streams. A substantial portion of this region with state and private forestlands is currently managed under HCPs. All state lands within the range of the northern spotted owl have been operating under a DNR HCP since 1997. This includes all of the Puget Sound region.

Olympic Coast

The Olympic Coast region includes coastal rivers and streams from the north of and including the Copalis River to the west of, but not including, the Elwha River. Overall stream density is relatively high in the region with 4.7 mi/mi². All of the priority species are present in the Olympic Coast Region. Bull trout are listed as threatened throughout the region and the Ozette Lake population of sockeye salmon is listed as threatened. Coho salmon is a candidate species. Of the 4-Hs, habitat appears to be the highest priority factor for bull trout. State and private forestlands include 63 percent of the fish-bearing streams and 57 percent of the nonfish-bearing streams. Federal management is also significant with 9 percent of the fish-bearing and 39 percent of nonfish-bearing streams. No significant hydroelectric facilities are present in the region and no hatcheries are stocking bull or sockeye salmon. However, small diversion dams for agricultural purposes are



Chapter 3

present in some watersheds. For the purposes of this EIS, only private commercial forestlands are considered because state lands are currently managed under an HCP.

Southwest

The Southwest Region includes coastal rivers and streams north of the Columbia River to the Grays Harbor drainage. This region has the highest overall stream density in the state (7.2 mi/mi²). All of the priority species are present in this region except sockeye salmon. Bull trout and cutthroat trout are listed in the region, but coho salmon is a candidate species. Streams in the region are substantially influenced by FPRs because 81 percent of fish-bearing and 91 percent of nonfish-bearing streams are on state or private forestlands. Federal management strategies have only a minor influence on streams in the region with no fish-bearing and 3.8 percent of nonfish-bearing streams on federal ownership. Similar to the Olympic Coast Region, habitat degradation appears to be the leading factor influencing listing of species in the region. State lands in the region are covered by an HCP.

Lower Columbia River

The Lower Columbia Region includes the Columbia River and rivers and streams that drain from Washington into the Columbia River from its mouth to streams west of (but exclusive of) Rock Creek. This region also has a very high stream density (5.6 mi/mi²). All of the priority species are present in this region. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook salmon, chum salmon, steelhead, and sea-run cutthroat trout are listed as threatened in the region and found downstream of Mossyrock Dam and Merwin Dam on the Cowlitz River and Lewis River, respectively. Bull trout are listed as threatened throughout the region where they are present. Coho salmon is a candidate species. State and private forestlands include 68 percent of the region's fish-bearing streams and 67 percent of the nonfish-bearing streams. Federal ownership includes about 8 percent of the fish-bearing and 28 percent of the nonfish-bearing streams. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (Table 3.7-1). State lands in the region are covered by an HCP.

Middle Columbia River

This region includes rivers and streams that drain from Washington State to the Columbia River from Rock Creek through the Yakima River, not including the Snake and Walla Walla Rivers which is considered separately in their own region. Overall, stream density (1.7 mi/mi²) is relatively low in the region, reflecting the relatively arid conditions in the eastern and southern parts of the region. All of the priority species are present in this region, except chum and sea-run cutthroat trout. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook and chum salmon are listed in the westernmost portions of this region as part of the lower Columbia River ESU, and steelhead are listed as threatened throughout the region except for the White Salmon River. Bull trout are present in many parts of the region, but their distribution has been fragmented by dams, degraded water quality and other factors. State and private forestlands include about 46 percent of the region's fish-bearing streams and 44



percent of the nonfish-bearing streams. Federal management strategies also have a significant influence on forested lands with about 18 percent of the fish-bearing and 36 percent of nonfish-bearing streams on federal ownership. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations).

Snake River

This region includes all portions of the Snake River and its tributaries that lie within Washington State. The region also includes the Walla Walla River drainage. The Snake River region is relatively arid and has a low stream density of 1.2 mi/mi². In addition, the region has a relatively low proportion of fish-bearing streams (about 6 percent, 342 miles). Chinook salmon, sockeye salmon, steelhead and bull trout are present in the region. However, sockeye salmon do not spawn or rear in the region but use the mainstem Snake River as a migration corridor. Sockeye spawning and rearing occur within Idaho. Chinook, steelhead, and bull trout are listed as threatened within the region. Chinook salmon and steelhead are not found upstream of a natural barrier on the Palouse River. In addition, chinook salmon are not listed within the Walla Walla drainage. About 33 percent of the fish-bearing streams and 20 percent of the nonfish-bearing streams are located on private forested lands. Few state lands are in the region. Federal management includes about 17 percent of fish-bearing streams and 43 percent of nonfish-bearing streams. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations). Relative to other regions, the Snake River region is relatively arid and does not include large amounts of commercial forestlands. Consequently, this region accounted for only 4 of the 188 sample sections used in the analysis.

Upper Columbia River downstream of Grand Coulee Dam

This region includes the mainstem of the Columbia River and its tributaries to Grand Coulee Dam. The region has a moderate stream density of 3.2 mi/mi². The major tributaries include the Wenatchee River, Methow River, Okanogan River, and Lake Chelan and its tributaries. The priority species found in the region include chinook salmon, sockeye salmon, steelhead, and bull trout. Chinook (endangered), steelhead (threatened), and bull trout (threatened) are listed within the region. Private forestlands include about 20 percent of the fish-bearing streams in the region and about 17 percent of the nonfish-bearing. Federal management is also very important in the region with 20 percent of the fish-bearing and 64 percent of the nonfish-bearing streams located on federal ownership. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations).

Upper Columbia River upstream of Grand Coulee Dam

This region includes all of the Columbia River mainstem and its tributaries upstream of Grand Coulee Dam within Washington. Major tributaries include the Sanpoil River, Spokane River, Kettle River, and Colville River. Stream density in region is relatively low with 2.8 mi/mi². Grand Coulee Dam is a complete barrier to anadromous fish. Consequently, the only priority species present in this region is bull trout which are listed



Chapter 3

as threatened. Hydroelectric and irrigation dams which have fragmented bull trout distribution plus habitat degradation have been cited as major factors leading to the listing in this region (Federal Register 63 No. 111). Private forestlands include about 31 percent of the fish-bearing streams and 32 percent of the nonfish-bearing streams. Relatively few state lands are present in the region which include about 6 percent of the nonfish-bearing and no fish-bearing streams. Federal management has an important influence in the region with 15 percent of the fish-bearing and 29 percent of nonfish-bearing streams within federal ownership.

3.7.3 Environmental Effects

The forest practices rules are designed to protect public resources to an acceptable level while maintaining an economically viable commercial forest industry. Defining what constitutes “an acceptable level” is public policy that results from both scientific inquiry and public discourse. However, the Forest Practices Board goals related to fish suggest that acceptability is the level that results in compliance to the ESA, and in the restoration and maintenance of riparian habitat needed to support a harvestable supply of fish.

Criteria for determining potential effects of the alternatives on priority fish species and aquatic habitat were based on two broad-scale perspectives:

- Management approaches under each alternative in riparian and upslope areas
- Habitat needs and biological requirements of priority fish species

The aquatic habitat in the planning area is extensive and complex. Current freshwater habitat conditions in many areas do not fully meet requirements for priority fish species. For example, at certain times of the year (e.g., during late summer), water temperatures in some streams exceed favorable levels for priority species. This is often associated with lack of streamside vegetation to provide shading. Such shading can reduce the water temperature, but can also be influenced by other factors such as weather conditions, air temperatures, elevations, and groundwater inflow.

In a broad sense, management approaches under each alternative are expected to affect aquatic habitat conditions in a similar manner. However, the magnitude of the effects may be different depending upon site-specific conditions. For example, conditions in some areas may be at or near levels that would support healthy populations of priority fish species and a change in management approach might not change that condition. This is particularly true for regions of the state that do not have significant state or commercial forestlands or lack the priority species for reasons unrelated to forest practices. In contrast, conditions in water quality limited streams may be less able to fully support populations of any priority fish species, and management changes could have a significant effect.

It is difficult to predict aquatic habitat conditions under a specific alternative, particularly if those predictions are for an extended period that could include significant changes in FPRs resulting from adaptive management (Appendix I). The reason for this difficulty is the complex and dynamic nature of the aquatic system and the surrounding terrestrial



environment (flooding, earthquakes, fire, and other major events that affect aquatic and streamside habitat).

Trends in aquatic habitat changes also involve a time consideration. For example, priority fish species have a relatively short life cycle (up to six years). In areas where habitat is degraded, habitat restoration would only begin to become effective after a longer period (greater than 10 years). Therefore, several life cycles of priority fish species may encounter less than desirable habitat conditions before any management measures become effective. However, a reduction in any factor that limits aquatic habitat in the planning area during the short term should establish a trend toward more favorable conditions for maintaining or recovering priority fish species.

When predictions cannot be precisely made, as is the situation when applying any of the alternatives to the planning area, monitoring is often required to determine if a trend toward favorable or target conditions is occurring and the strength of that trend. For example, monitoring of water temperature at various locations over a number of years would provide the information needed to determine if a trend toward lower temperatures (e.g., in late summer) could be correlated with increasing re-growth of streamside vegetation.

Evaluation of the environmental consequences on aquatic resources focused on the strength of the trends that the management conditions would have in achieving target conditions under each alternative. A strong trend in changes leading to attainment of target conditions would indicate that maintaining or restoring priority fish populations is more probable than under weaker trends. Even with conditions meeting requirements for a properly functioning aquatic system, however, there is no certainty that current populations will be maintained or recover.

It is impossible to precisely predict specific salmon population numbers for any particular alternative. It is also impossible to precisely predict other factors (e.g., ocean conditions, predation, disease, harvest, or competition) that may affect these populations. Therefore, the environmental assessment of potential effects has been focused on habitat requirements. If habitat is properly functioning, then other factors need to be assessed to determine why chinook salmon and other salmonid species are either depressed or at risk of extinction.

To achieve a properly functioning aquatic system and to safeguard priority fish species or populations, unlimited or complete protection across a landscape is not needed to maintain habitat conditions at an acceptable level. There is a point beyond which, for example, the width of an RMZ would not provide any significant additional levels of protection. For instance, stream buffers greater than about 100 feet with 80 percent canopy closure would not provide additional shade to reduce stream temperature (see Section 3.5). Less than full protection can achieve target conditions because it is the full range of management prescriptions (including for slopes and roads) and the totality of riparian function that must be considered in aggregate. In addition, forest practices often occur within a mosaic of other land use practices with different levels of protection. For example, private or state



Chapter 3

timber lands can be adjacent to National Forest lands that are managed to meet different goals. Timber harvest activities on National Forest lands on the west side of the state follow guidelines in the President's Forest Plan. Prescriptions that provide substantial LWD and detritus input, shading, coarse and fine sediment control, and streambank stability, for example, can set a trend toward achieving target conditions and a properly functioning aquatic system.

Because the threshold of significance for fish and aquatic habitat considers the effects of an aggregate of management prescriptions in each alternative, this section relies on the conclusions of several other sections. For example, the amount of LWD that is recruited to a stream is determined by RMZ width and the number of trees prescribed to remain in it (see Section 3.5). Similarly, potential changes in erosion and sediment from upslope areas or from roads also directly affect aquatic habitat conditions (see Sections 3.2 and 3.5). Evaluation criteria for measuring effects from riparian and upslope management are identified below in Section 3.7.3.1.

The following section (Section 3.7.3.2) evaluates these individual criteria and aggregates their overall effects on the aquatic system to determine if an individual alternative provides the likelihood of achieving target conditions (i.e., properly functioning aquatic system) and does not threaten individual priority fish species or fish populations. The concluding section (Section 3.7.3.7 Synthesis) attempts to place lands regulated under FPRs in perspective with other practices that affect Pacific salmon and trout viability.

3.7.3.1 Issues and Evaluation Criteria

Issues relevant to fish resources were identified during the scoping process described in Chapter 1. The issues were categorized according to NMFS matrix of pathways and indicators of a properly functioning aquatic ecosystem (NMFS, 1996). The issue categories evaluated here include the following:

- Coarse sediment
- Fine sediment
- Hydrology
- Large woody debris
- Leaf and needle litter
- Floodplains and off-channel features
- Water temperature
- Forest chemicals
- Fish passage

One or more measures and evaluation criteria were identified for each of the issues and is used to compare and contrast the likely effects of implementing each of the alternatives. As described earlier, the measures used in this section are drawn primarily from other sections of this document. The goal of this chapter is to synthesize and examine these measures and others as they relate to the priority fish species and a properly functioning aquatic ecosystem. The following is a brief description of the issues and their measures



and criteria. Most of the descriptions will refer the reader to previous sections where more complete descriptions have been provided.

Coarse Sediment

Coarse sediment affects the amount of spawning habitat, pool filling, bank stability, and stream hydrology. The three alternatives address coarse sediment delivery to streams from forest practices by protecting streams from accelerated coarse sediment production from mass wasting and reducing coarse sediment production from road and culvert failures.

The effects of the alternatives on coarse sediment production from mass wasting and roads were evaluated in the Sediment and Channel Conditions Section (Section 3.2.3). Mass wasting was evaluated by comparing the proportion of area within the RMZs and upslope areas that contain moderate to high hazard areas. Coarse sediment production from roads was analyzed by qualitative evaluation of road management practices under the three alternatives.

Fine Sediment

High levels of fine sediment in streams can be detrimental to the survival of eggs and fry incubating in redds. Sources of fine sediment can include hillslope erosion, surface erosion from roads, unstable stream banks, mass wasting, and culvert failure. Vegetation in RMZs provide filtering of fine sediments from upslope areas and stability to stream banks. The effect of the alternatives on hillslope erosion and bank stability was evaluated in the Sediment and Channel Dynamics Section (Section 3.2.3). Hillslope erosion was evaluated by comparing the percent of riparian vegetation that is protected under the different management prescriptions for the different stream types and regions using the EBAI. The bank stability evaluation was based upon the percentage of the riparian area important for stream bank stability that is protected by different management prescriptions.

Improperly constructed and maintained forest roads can also be an important source of fine sediments. Furthermore, stream crossings can be the location of direct delivery of fine sediments into streams. Numerous factors can affect the production and delivery of fine sediment from roads including the number of road miles, the construction materials, road drainage structures, the level of use and maintenance, and the number of stream crossings. The Road Analysis Appendix provides a more complete description of these and other factors and assesses the risk of sediment delivery from roads among the three alternatives.

Hydrology

The amount of timber harvest in a watershed and the forest road density can affect the hydrologic regime of a stream. Particularly in rain-on-snow regions, immature forest stands and high levels of road density can result in higher frequency and higher magnitude of peak flow events. This issue was evaluated for the alternatives in Section 3.3 (Hydrology) by considering the effect of the alternatives on the percentage of a watershed to be harvested and on limiting road densities.



Chapter 3

Large Woody Debris

LWD is one of the most important components of high quality Pacific salmon and trout habitat affecting nutrients, food, cover, and channel morphology. The effects of the alternatives on LWD recruitment have been evaluated previously in the Riparian Habitat Section (Section 3.4) using the EBAI as comparative tool for alternative RMZ management prescriptions.

Leaf/Needle Litter Recruitment

Leaf and needle litter is an important nutrient source for forested streams and can be affected by harvest within or near riparian zones (Bilby and Bisson, 1992). The effects of the alternatives on leaf and needle litter recruitment have been evaluated previously in the Riparian Habitat Section (Section 3.5) using 0.5 SPTH as a criteria for protecting most leaf and needle litter inputs to streams.

Floodplains and Off-channel Areas

Floodplains and off-channel areas are an important component of aquatic habitat that include side channels, backwater alcoves, ponds, and wetlands. The effects of the alternatives on floodplain and off-channel areas were evaluated in the Sediment Section based upon a qualitative analysis of the different prescriptive features of the alternatives (Section 3.2.3).

Water Temperature

As described in Section 3.7.2.2, Pacific salmon and trout require cool, clean water to thrive. Stream shading is an important component to regulating stream temperatures. The effect of the alternatives on shade levels has been evaluated in the Riparian Habitat Section (Section 3.4.3.2) by comparing the percent of riparian vegetation that is protected under the different management prescriptions for the different stream types and regions.

Forest Chemicals

Fish production and water quality can also be affected by the presence of pesticides used to control undesirable plants, insects, and fungi. Pesticide use is an important management tool for speeding reforestation by reducing competition and disease. Pesticide use under the three alternatives is described and evaluated in Appendix J (Forest Chemicals). For evaluation of this component to water quality, minimum buffer widths along surface water bodies were used as the comparative measure among the alternatives.

Fish Passage

One of the important ways that forest practices affect the ability of fish utilize all of the available habitat is through barriers at stream crossings by roads. Historical road building under much less conservative rules than currently practiced has sometimes led to habitat loss without documenting historical fish utilization. Consequently, the current known distribution of fish is generally recognized to be much smaller than historically existed. Criteria for the construction of stream crossing structures are currently based, in part, on whether a stream is fish-bearing (WAC 222-24-040). For example, culverts must be a minimum diameter of 24 inches for streams with anadromous fish and a minimum diameter



of 18 inches for streams with resident game fish. Therefore, the assumptions made in determining a fish-bearing stream are critical for the construction of new stream crossings and for evaluating whether existing stream crossings meet FPRs.

The evaluation of the potential effects of the alternatives on fish passage will be based primarily upon how the rules will change stream typing assumptions and the effect this will have on new stream crossing construction and compliance of existing structures. The measure to be utilized will be proportion of stream miles that are considered to fish-bearing versus nonfish-bearing. In addition, a qualitative comparison will be made on the alternative programs for decommissioning roads, road maintenance, and replacement of problem culverts.

3.7.3.2 Alternatives Analysis

This section presents a synthesis of the results of the alternative evaluations for each issue as they relate to the fish resource. Tables 3.7-4 and 3.7-5 summarizes the outcome of the evaluations determined within this and other sections of this EIS.

Coarse Sediment

Coarse sediment loading levels to streams results primarily from three sources: mass wasting events, road failures, and stream bank instability. Mass wasting and road failures can deliver large, but infrequent inputs of coarse and fine sediment to streams. In contrast, stream bank instability can be a chronic problem resulting from changes in riparian root-strength and/or hydrology. In one sense, stream bank instability does not provide any new sediment to the stream. However, it does change the amount of sediment that is mobile and its distribution along the channel. Mass wasting is a natural phenomenon that occurs in watersheds without any major land-use activities. Both mass wasting (including debris flows) and stream bank stability are natural channel processes and can be an important source of coarse sediment and LWD to streams. However, forest practices have been implicated in increasing the natural frequency of mass wasting events and the amount of stream bank instability. The two major factors that contribute to increased mass wasting and decreased bank stability are timber harvest and roads. Timber harvest on high hazard slopes can increase the risk of mass wasting events by removal of tree root strength that helps maintain soil cohesion. Forest roads can increase mass wasting risk by placing roads on high hazard landforms, concentrating water drainage in high hazard areas, and

Table 3.7-4. Estimated Level of Risk Associated with Issues Related to the Fish Resource in Westside Streams

Issue	Alternative 1	Alternative 2		Alternative 3	EIS Section
		Option 1	Option 2		
Coarse Sediment	Moderate	Low to Moderate	Low to Moderate	Low to Moderate	3.2
Fine Sediment	High	Moderate	Moderate	Low to Moderate	3.2
Hydrology	Moderate	Moderate	Moderate	Low	3.3



Chapter 3

Large Woody Debris	High	Low to Moderate	Low to Moderate	Low to Very Low	3.4
Leaf/Needle Recruitment	High	Moderate	Moderate	Very Low	3.4
Floodplains and Off-Channel Areas	High	Low	Low	Low	3.7
Water Temperature	Moderate	Low to Moderate	Low	Very Low	3.5
Forest Chemicals	Moderate	Low	Low	Low	3.6
Fish Passage	High	Low	Low	Low	3.6

Table 3.7-5. Estimated Level of Risk Associated with Issues Related to the Fish Resource in Eastside Streams

Issue	Alternative 1	Alternative 2	Alternative 3	EIS Section
Coarse Sediment	Moderate	Low to Moderate	Low to Moderate	3.2
Fine Sediment	High	Moderate	Low to Moderate	3.2
Hydrology	Moderate	Moderate	Low	3.3
Large Woody Debris	High	Moderate to High	Low to Very Low	3.4
Leaf/Needle Recruitment	High	Moderate	Very Low	3.4
Floodplains and Off-Channel Areas	High	Low	Low	3.7
Water Temperature	Moderate	Low to Moderate	Very Low	3.6
Forest Chemicals	Moderate	Low	Low	3.6
Fish Passage	High	Low	Low	3.7



culvert failures. Road-related mass wasting often has higher negative effects to streams because initiation points can occur at stream crossings.

ALTERNATIVE 1

Under Alternative 1, harvest and road-related mass wasting events would continue to adversely affect fish habitat in local areas.

Under Alternative 1, the current rate of harvest-related and road-related mass wasting events are expected to continue and risk from mass wasting is considered to be moderate (Section 3.2 Sediment). New roads crossing unstable slopes require Class IV special permits, but no standardized method is currently in use for identifying unstable slopes. Currently, to the extent possible, unstable slopes are identified in watershed analysis and forest practices applications. Existing roads would only be upgraded following watershed analysis or forest practices applications. Rarely used roads greater than 10 years old and orphaned roads would continue to be at high risk of failure in some areas. Streambank stability is also likely to be periodically reduced along all westside and eastside streams subject to adjacent harvest. Fish-bearing streams (Types 1 to 3) will have some protection provided by RMZs, but selective harvest within the RMZs would result in less than full protection. In addition, Type 4 and 5 waters would have no protection resulting from RMZs. Depending on tree species, loss of root strength by root die-back and decline of streambank stability after timber harvest can take as long as 5 years while restoration of stability from new tree and vegetation growth may take more than 12 years. Overall, the risk to streams from excessive coarse sediment delivery is considered moderate.

ALTERNATIVES 2 AND 3

Coarse sediment, resulting from new forest practices would result in a low to moderate risk of effects on fish habitat under Alternative 2. However, existing roads would continue to produce moderate effects in the short term, with a reduction in the effect over time and a low risk under Alternative 3.

Relative to Alternative 1, Alternatives 2 and 3 would receive greater protection from harvest-related mass wasting because a more-refined and uniform high hazard screening method would be implemented. Greater success in identifying high hazard slopes should result in more Class IV-special applications, greater scrutiny, and implementation of more restrictive harvest prescriptions for these areas. Alternative 3 has higher protection to streams from harvest-related mass wasting events compared to Alternative 2 because it includes wider no-harvest buffers on all streams. Overall, Alternatives 2 and 3 are rated as having moderate and low levels of risk for harvest-related mass wasting, respectively.

Under Alternatives 2 and 3, significant improvements would occur in the planning and implementation of new roads (see Appendix F). Relative to Alternative 1, more new roads planned for potentially unstable slopes (based upon new DNR hazard maps) would require a Class IV- special application that would result in greater scrutiny. Alternatives 2 and 3 also require the preparation of RMAPs. The RMAPs would require inventories of roads and work plans for improvements of identified problems. Alternatives 2 and 3 also require road upgrades to new standards within 10 to 15 years (Alternative 3 and 2, respectively). Alternative 3 also requires a cap at current road densities. Relative to roads, Alternatives 2 and 3 are considered to have low to moderate risk of adverse effects. It is probable that some coarse sediment delivery to streams from forest roads would occur regardless of management activities (exclusive of decommissioning all moderate to high risk roads); however, the frequency and magnitude of events should be substantially reduced.

Under both harvest prescription options, Alternative 2 provides substantial streambank protection compared to Alternative 1, but does not provide full protection. Changes in the



Chapter 3

stream typing system (see Fish Passage below) and the presence of no-harvest core zones substantially increases the number of Type F and S stream miles that receive a relatively high level of protection. However, up to 50 percent of Type N_P stream reaches and all Type N_S reaches would receive no protection from harvest, but would have equipment limitation zones. Consequently, there would be a moderate risk that coarse sediment would be delivered from Type N to Type F and S streams.

Alternative 3 provides complete bank stability protection for nearly all streams. The RMZ widths proposed under this alternative are at least 70 percent of the one-half site-potential tree height and exceed this criterion under most situations. In addition, the RMZs include a no-harvest prescription. Consequently, Alternative 3 is rated as having a low risk of bank instability while Alternative 2 is rated as low to moderate risk and Alternative 1 is rated as high risk.

COARSE SEDIMENT: CONCLUSION

Alternative 1 has a high risk of coarse sediment delivery. Alternatives 2 and 3 would both have low to moderate levels of risk. Alternative 3 is considered to provide slightly lower risk than Alternative 2 because it includes wider no-harvest buffers, an accelerated schedule for implementing RMAPs, and no net increase in road densities. Both Alternatives 2 and 3 would potentially have lower risk in the long-term through the implementation of the monitoring and adaptive management plan. Higher levels of protection would result in less stream bed aggradation resulting from forest practices and a reduction in the risk of habitat degradation from pool filling and modified channel capacity.

Fine Sediment

Fine sediment loading to streams affects the quality and quantity of spawning and rearing habitat by filling in the spaces between gravels and cobbles and by filling pools. Similar to coarse sediment loading, fine sediment production is related to both timber harvest and road management practices. Vegetation in riparian zones is important for filtering and retaining fine sediment eroding from hillslope areas. Similar to coarse sediment, some fine sediment is delivered to streams during infrequent mass wasting events and road failures. In addition, roads can be a chronic source of fines from surface erosion, and harvest activities can contribute to increases in hillslope erosion. The EBAI for sediment was calculated for the proposed management prescriptions under the three alternatives (see Appendix C, Riparian Habitat Appendix). In addition, the maximum EBAI for a no harvest condition was also calculated for comparison.



ALTERNATIVE 1

Alternative 1 would result in high risk of adverse effects on fish habitat in many areas from fine sediment delivery to streams.

Under Alternative 1, the EBAI for sediment was calculated as about 64 percent of the maximum EBAI (full protection). The difference between the level of protection for eastside and westside stands was less than 1 percent. Consequently, Alternative 1 is considered to provide high risk of hillslope erosion.

Under Alternative 1, the current approach to road management is based primarily upon the implementation of best management practices (BMPs) that have been approved by the Department of Ecology and described under the Forest Practices Rules and the Forest Practices Board Manual. In addition, many of the rules include discretionary language by encouraging, but not requiring, certain activities. Unfortunately, a recent study on the effectiveness of BMPs for new road construction found that many practices were ineffective even when implemented according to standards and guidelines (Rashin et al., 1999, see Appendix F). Other activities such as preparation of a road maintenance and abandonment plan or additional maintenance or culverts only occur when asked for by the DNR. However, there are no descriptions of specific triggers that would prompt the DNR to require these activities. Under current FPRs there appears to be little incentive for landowners to abandon (i.e., close and remediate) roads. Consequently, many roads remain in an inactive status with minimal maintenance requirements because abandonment requires activities such as stream crossing removal. Roads built before 1974 and unused since 1974 have been termed “orphan” roads. The current FPRs have no policies directed towards management of orphan roads. Alternative 1 is considered to have high risk for the delivery of fine sediment from roads to streams.

ALTERNATIVES 2 AND 3

Alternative 2 would result in low to moderate risk and Alternative 3 would result in low risk of adverse effects on fish habitat from fine sediment delivery to streams. There is a high degree of uncertainty regarding the effectiveness of protections along Type N streams with Alternative 2.

The EBAI suggests that Alternative 2 would provide about 80 percent protection relative to no harvest in the RMZ. The EBAI suggests that Alternative 3 would provide a level of protection that is 100 percent of the maximum EBAI. The EBAI for sedimentation suggests that Alternative 3 would provide the maximum level of sediment filtering while Alternative 2 would provide a relatively high level of protection. Both Alternatives 2 and 3 would provide substantially more sediment filtering protection than Alternative 1.

Road maintenance and abandonment plans are not required under current regulations unless requested by DNR and their contents are not specified. Furthermore, there are no specific requirements for road maintenance or provisions for orphaned roads (not used since 1974). Alternatives 2 and 3 significantly improve the current regulations by requiring landowners with greater than 500 acres of forestland to prepare road maintenance and abandonment plans within five years if watershed analysis has not been completed. Alternatives 2 and 3 differ in that upgrades identified in the plans must be completed within 15 years for Alternative 2 and within 10 years for Alternative 3. The schedule for correcting problem orphan roads is also different among Alternatives 2 and 3. Under Alternative 2, activities on problem orphan roads will not begin for 5 years after all large landowner RMAPs have been submitted. In contrast, Alternative 3 requires that activities to fix problem orphan roads occur on the same schedule as other roads. In addition to scheduling differences, Alternative 3 requires a no net increase in road density within an



Chapter 3

ownership or watershed and occurs concurrently with implementation of RMAPs. Small landowners (less than 500 acres) are also required to prepare RMAPs, but are not required to submit them until their first Forest Practice Application.

An important component to RMAP preparation is review. Under Alternatives 2 and 3, RMAPs will be open to review by WDFW, Tribal entities, and the Washington State Department of Ecology. However, the authority to require changes to an RMAP will be held solely by DNR. Similar to other components to the Forest and Fish Plan, adaptive management is key to ensuring that positive results occur. Monitoring will be important to ensure that revised road BMPs in the Board Manual are implemented and effective. Ineffective BMPs will require strengthening. Alternative 3 provides a small, but significant, added level of protection over Alternative 2 by capping road densities at current levels.

Many watersheds are currently at road densities considered too high for a properly functioning aquatic ecosystem (less than 2 mi/mi², NMFS, 1996; less than 1 mi/mi², USFWS, 1998). However, road density criteria should be viewed with caution because the functional relationship between road density and effects to the aquatic ecosystem can vary among different watersheds depending upon watershed characteristics (soil, climate, and topography) and characteristics of the road system (age, usage, and level of maintenance). Nevertheless, road density can be a useful descriptor to enhance understanding the overall level of disturbance to a watershed. Notably, road density is only one of nineteen physical indicators recommended by NMFS and USFWS to assess a properly functioning aquatic ecosystem, including several that evaluate road effects more directly (e.g., sediment and channel condition).

Of the three alternatives, Alternative 3 provides the lowest risk to streams from the delivery of fine sediment from roads due to the “no net increase” clause and accelerated improvement schedule. However, it is followed closely by Alternative 2. It is unlikely that road surface erosion and delivery to streams can be eliminated under any of the alternatives. In part, this results from the highly developed forest road network that currently exists and the lack of requirements to reduce the network. Alternatives 2 and 3 can provide significant improvements, primarily through the requirement that roads meet upgraded road standards within 10 (Alternative 3) or 15 (Alternative 2) years. Furthermore, the requirement for road maintenance and abandonment plans would improve ongoing road conditions.

FINE SEDIMENT: CONCLUSION

Considering both harvest-related and road-related management prescriptions including mass wasting and road failure from above, Alternative 1 is considered to be at high risk for the delivery of fine sediment to streams. Alternative 2 is considered to be at a moderate level of risk to streams, primarily because of the requirements for RMAPs and road upgrades. Alternative 3 is considered to be low risk because no-harvest buffers are more extensive, RMAP implementation is accelerated, and because it includes a “no net increase” clause for road density. Similar to the coarse sediment discussion, implementation of the monitoring and adaptive management plan would potentially



provide higher levels of protection for Alternatives 2 and 3. Although Alternatives 2 and 3 would provide substantial improvements over Alternative 1, none of the alternatives would be expected to eliminate all risk of fine sediment deposition from forest practices.

Hydrology

Forest roads and timber harvest can affect the hydrologic regime of a stream. High levels of road density and immature forest stands, particularly in rain-on-snow regions, can result in a higher frequency and higher magnitude of peak flow events. Roads influence stream hydrology by routing water collected on the road surface. The primary negative effect of peak flows to salmonids occurs while eggs incubate in redds, but other effects include accelerated bank erosion and changes in channel morphology. Peak flows can result in scour that disturbs the highly sensitive eggs and causes increased mortality.

Alternatives 1 and 2 would result in moderate risk of effects on peak flows. Alternative 2 would have slightly less protection because fewer watershed analyses would be performed, but would have more protection because it addresses road drainage more effectively.

Under Alternative 1, the risk of effects on peak flow events is reduced in areas that have watershed analysis. The DNR is required by state law to conduct watershed analysis within all non-agricultural watersheds of the state with more than 1,000 acres of forested land and less than 80 percent federal ownership. A watershed analysis can be prepared voluntarily by a private landowner. Under Alternative 1, watershed analysis provides landowners with increased certainty about the prescriptions that would be required on their lands and aided in the planning of their management. Alternative 1 is considered to have a moderate level of risk because watershed analysis would provide more restrictive prescriptions in westside watersheds where risk of peak-flow events is high. However, many watershed analyses have remained incomplete because negotiations during the prescriptive phase have stalled (M. Hunter, WDFW, personal communication, February 2001). Consequently, the effectiveness of watershed analysis in providing added protections has declined in recent years.

Alternative 2 would have a slightly higher risk of effects on peak flows in the near-term, relative to Alternative 1, because fewer watershed analyses are likely to be performed by private landowners. Under Alternative 2, the prescriptive phase of watershed analysis for riparian zones would be deleted and the certainty of prescriptive measures would be contained within the new riparian strategies implemented by changes in the Forest Practices Rules. In addition, watershed analysis under Alternatives 2 and 3 would have more modules that would make them more costly to conduct. Consequently, many of the benefits of watershed analysis would likely be delayed until the DNR conducted the analyses and incorporated the results during their review of FPAs. The level of risk from peak flows provided under Alternative 2 is considered slightly higher than Alternative 1, but still moderate.

Alternative 3 would result in low risk of effects on peak flows because it addresses cumulative watershed harvest in the ROS zone.

In the long-term, Alternative 3 would provide the lowest risk from peak flows relative to Alternatives 1 and 2 because it includes rules restricting the amount of hydrologically immature stands that could be present within the rain-on-snow zone and watershed analysis would incorporate a new eastside hydrology module. The differences in the alternatives relative to potential effects on peak flows are more apparent in westside watersheds than eastside watersheds because rain-on-snow zones are more prevalent on the west side.



Chapter 3

Road-related effects on peak flow in forested watersheds are relatively minor compared to harvest-related effects. Consequently, Alternatives 2 and 3 are considered to have similar road prescriptions that would provide only slight improvements relative to Alternative 1 for addressing peak flow issues. Improvements to the road system resulting from RMAPs should provide some added protection; however, neither Alternative 2 nor Alternative 3 requires reductions in road density over current levels. Alternative 3 does provide a cap on road density.

HYDROLOGY: CONCLUSION

Overall, Alternatives 1 and 2 are considered to have moderate risk to streams from peak flow events on the west side and moderate protection on the east side, but Alternative 1 provides slightly less risk as a result of regulatory incentives for the implementation of watershed analysis by private landowners. Alternative 3 is considered to be low risk because it would limit the size of clearcuts in the rain-on-snow zone.

Large Woody Debris

Instream LWD is considered by many to be the highest priority habitat component lacking in most streams categorized as “not properly functioning.” Large woody debris levels have declined for a number of reasons including splash dams, logjam removal programs, removal at dam trashracks, removal for firewood, and low recruitment from forest practices. This portion of the assessment evaluates the level of protection and enhancement the alternatives provide for instream LWD using the EBAI described in the Riparian Habitat Section and Appendix D. As a reference point the analysis assumed that a no-harvest buffer width that was one site potential tree height would provide full protection. Consequently, all EBAI values for the alternatives were relative to the full protection EBAI value (i.e., 0.0 is no protection, 1.0 is full protection). EBAI analyses were conducted based upon both a 100-year SPTH and 250-year SPTH assumption (see Section 3.4).

ALTERNATIVE 1

Alternative 1 would likely contribute to continued degradation of fish habitat due to inadequate recruitment of LWD on both eastside and westside forests.

Under Alternative 1, current FPRs would continue to regulate RMZ widths. Westside RMZ widths range from 25 feet to 100 feet for fish-bearing streams (Types 1 to 3) depending upon the stream type and width. Similarly, in eastside forests, RMZ widths range from 30 feet to 300 feet for fish-bearing waters depending upon the harvest prescription (partial versus even-aged) in the adjacent harvest unit. RMZs are not required along nonfish-bearing streams (Types 4 and 5), except occasionally along the lower 1,000 feet of Type 4 waters to protect public water resources. In addition to the RMZ widths, the FPRs provide guidance on the number of leave trees required within the RMZs.

The EBAI suggests that Type 1 to 3 streams in eastern Washington would receive about 27 percent of full protection that would be available from a no-harvest buffer under the 100-year SPTH assumption and about 20 percent of full protection under the 250-year SPTH assumption. All streams combined would receive about 14 to 19 percent of full protection (Tables 3.7-6 and 3.7-7). Consequently, Alternative 1 is considered to be at high risk of having inadequate LWD recruitment potential. In western Washington, protection levels would be higher. Type 1 to 3 streams would have about 48 percent of full protection while



all streams combined would have about 26 percent of full protection under a 100-year SPTH assumption. Type 1 to 3 streams would have about 38 percent of full protection while all streams would have about 21 percent of full protection under a 250-year SPTH (Tables 3.7-6 and 3.7-7). Relative to the other alternatives, Alternative 1 has the highest level of risk of reduced LWD recruitment potential to streams.

ALTERNATIVE 2

Alternative 2 would likely provide adequate direct LWD inputs to fish-bearing streams on the west side under both Option 1 and Option 2.

Under Alternative 2, the stream typing system would change and new rules for RMZ widths and harvest prescriptions would be implemented. Total RMZ widths for fish-bearing streams would range from 90 feet to 200 feet on the west side and 75 feet to 130 feet on east side depending upon the site class (see Chapter 2). Unlike Alternative 1, nonfish-bearing streams (Type N) would have RMZs over at least 50 percent of their length and would provide protection for sensitive areas. As described earlier, RMZs along fish-bearing streams would incorporate three smaller zones, a no harvest core zone, an inner zone, and an outer zone. On the west side, landowners have two harvest prescription options for inner zones which exceed basal area stand requirements, Option 1 which allows thinning in the inner zone to accelerate riparian tree growth, or Option 2 which requires any tree harvest in the inner zone to occur at its outer edge. On the east side, harvest prescriptions are dependent upon the habitat type and the basal area of the stand in the inner zone. On both sides of the Cascades, outer zones have leave tree requirements that may be dispersed or clumped.

Table 3.7-6. Percentage of Full Protection for LWD Recruitment to Streams under a 100-year SPTH Assumption Based upon the EBAI Analysis

Region/Stream Type	Alternative 2			Alternative 3
	Alternative 1	Option 1	Option 2	
West side—Fish-bearing	48	96	94	99
West side—All streams	26	52	52	96
East side—Fish-bearing	27	73 ¹	---	100
East side—All streams	19	43 ¹	---	99

¹. Does not include additional potential protection within the bull trout overlay



Chapter 3

Table 3.7-7. Percentage of Full Protection for LWD Recruitment to Streams under a 250-year SPTH Assumption Based upon the EBAI Analysis

Region/Stream Type	Alternative 2			
	Alternative 1	Option 1	Option 2	Alternative 3
West side—Fish-bearing	38	85	81	95
West side—All streams	21	46	44	90
East side—Fish-bearing	20	54 ¹	---	95
East side—All streams	14	30 ¹	---	90

¹ Does not include additional potential protection within the bull trout overlay

It is uncertain whether Alternative 2 provides adequate protection for LWD recruitment from non fish-bearing streams to fish-bearing streams.

The EBAI indicates that Alternative 2 would provide considerably more protection than Alternative 1 under both the 100-year and 250-year SPTH assumptions. On the west side, Option 2 provides a high level of protection to Type S and F streams (81 to 94 percent of full protection (Tables 3.7-6 and 3.7-7) but for all streams, the level of protection would be much lower (about 44 to 52 percent of full protection). The lower level of protection indicated for all streams results from prescriptions on Type N streams which produce LWD that have a lower value for fish habitat creation. This is because trees from the smaller nonfish-bearing streams must be transported downstream during flood or debris flow events to become functional for the creation of fish habitat. In some areas, this can be a significant influx of wood. In coastal Oregon, 11 to 49 percent of the LWD in 2nd and 3rd order streams was derived from debris flows (Gresswell and May, 2000). However, the scientific literature does not provide clear guidance that buffers on Type N streams under Alternative 2 are sufficient for providing LWD to fish-bearing streams. See Section 3.4 (Riparian Habitat) for additional discussion of these prescriptions.

Alternative 2 would produce a moderate risk of diminished LWD recruitment to fish-bearing streams on the eastside; it is uncertain how strongly diminished LWD recruitment in non-fish-bearing streams affects downstream fish habitats.

Landowners on the west side that implemented Option 1 would provide about 85 percent (250-year SPTH) to 96 percent (100-year SPTH) of the assumed full protection level for Type S and F streams and about 46 to 52 percent protection for all streams. On the east side, the EBAI of Type S and F streams would be about 54 percent (250-year SPTH) to 73 percent (100-year SPTH) of the assumed full protection level. Overall, this suggests that under Alternative 2, most streams on the west side currently deprived of wood should eventually return to at least a moderate level of function. Depending upon site specific conditions and the Option chosen by the landowner, LWD function could be even higher.

On the east side, Alternative 2 provides substantial improvements over Alternative 1, but it provides a lower proportion of full LWD recruitment relative to the west side, and the range between the 100-year and 250-year SPTH assumptions is wider. The precise level of LWD required is unknown and different for different species (Bisson et al., 1987). Consequently, the level of uncertainty that eastside streams may be under-protected is higher and the risk level is estimated to range from moderate (100-year SPTH) to high (250-year SPTH).

One aspect of LWD recruitment that the EBAI does not reflect is the growth rate and future size of trees in the RMZ following implementation of a harvest prescription (see the



Riparian Habitat Section). The tree growth model in the Riparian Aquatic Integration Simulator (RAIS; see Appendix D) indicated that thinning increases the rate of growth for remaining trees. Larger streams require larger pieces of LWD to function adequately. Consequently, for larger streams and rivers, the EBAI would underestimate the protection available under Option 1. In situations where the RMZ stand is characterized by numerous, but smaller trees, Option 1 would more rapidly result in a future condition of fewer larger trees that have a higher potential to be functional once recruited to the stream. However, the RAIS model suggests stand ages that include trees of functional wood size range from 80 to 150 years depending upon stream size and site class. Consequently, the benefits from thinning become available in the long-term.

In addition to future stand conditions, the EBAI does not reflect instream wood placement strategies that can be implemented when existing stream adjacent roads result in the inability to meet basal stand requirements. Under these situations, a landowner may design a LWD placement plan in cooperation with the WDFW. Optionally, the LWD placement plan can include removing up to 10 trees per acre in the outer zone as incentives for landowners to implement the plan. Specifications of the required information in a LWD plan are currently under development.

Alternative 2 includes an option for hardwood conversion to conifers within inner zones that meet specific requirements (see Section 3.4.3.2). The hardwood conversion rule is intended to improve inner zone riparian areas over the long-term in areas that cannot meet basal stand requirements because of over-stocking by hardwood trees. These areas must also have evidence that conifers historically dominated the site. The rule provides for harvest of no more than 10 percent of the conifers 8 to 20 inches dbh and none larger. In terms of LWD, the hardwood conversion rule is considered a long-term benefit to these riparian areas. Alternative 3 also includes a hardwood conversion option.

Similar to Alternative 1, downstream movement of LWD can be restricted at culverts. However, Alternatives 2 and 3 include the preparation of Road Maintenance and Abandonment Plans (RMAPs). These plans include a change in culvert size requirement from the ability to pass water from a 50-year flood to a 100-year flood. All new culverts, and culverts that currently degrade resources will be required to meet the new rule. Larger culverts will have the ability to pass larger pieces of wood as well as floodwaters. However, culverts will not be able to pass all wood and some may build-up on the upstream side of a culvert. To the extent practicable without significant soil disturbance, RMAPs are required to include measures for moving built-up LWD from above to below culverts during standard road maintenance. Consequently, both Alternatives 2 and 3 have less risk than Alternative 1 for limiting LWD redistribution.

ALTERNATIVE 3

Alternative 3 is considered to have a low to very low level of risk of reduced LWD recruitment. Under Alternative 3, all streams would receive 95 to 96 percent of full protection under the 250-year and 100-year SPTH assumptions, respectively, from the 70 to 200-foot no-harvest RMZs proposed. Notably, heavily stocked stands with small trees near large streams will have less opportunity for thinning to accelerate stand growth and

Alternative 3 would provide low risk of diminished LWD recruitment along eastside and westside fish-bearing and non-fish-bearing streams.



Chapter 3

average tree size. Under Alternative 3, thinning can only be done to convert hardwood-dominated stands to conifers and to accelerate development of 200-yr stand characteristics. However, these prescriptions would require SEPA review and cut trees could not be removed and sold unless monitoring determined that the prescriptions were effective. These requirements would provide little incentive for landowners to pursue these options.

Significantly, Alternative 3 provides no incentives or mechanisms for implementing instream wood placement strategies. Consequently, streams that have the potential for instream LWD placement under Alternative 2 will require more time for recovery. For LWD-poor streams surrounded by early- to mid-seral stage riparian stands, recovery could require 40 or more years on the west side and 60 or more years on the east side.

LARGE WOODY DEBRIS: CONCLUSION

Overall, LWD levels would be expected to gradually increase under Alternatives 2 and 3. Without any RMZ management, Alternative 3 is likely to provide the highest level of long-term protection and is considered to have the lowest level of risk of the alternatives. On the west side, Alternative 2 is considered to have a low to moderate level of risk for inadequate recruitment potential for functional LWD that can contribute to fish habitat in the long-term and provides incentives for landowners to commit to instream LWD enhancement plans and accelerate recovery of over-stocked riparian zones through thinning. The moderate level of risk is particularly relevant for streams with high levels of LWD recruitment from Type N streams. On the east side, Alternative 2 is considered to have a moderate to high level of risk for inadequate LWD recruitment potential. The call for the east side is based primarily upon the EBAI results which suggest that east side has between 54 and 73 percent of full protection along Type S and F streams, depending upon the SPTH assumption, but also considers that some additional reduction is likely from stream parallel roads. Alternative 1 would provide the lowest level of protection for LWD recruitment to streams and would likely contribute to continued degradation of fish habitat and is considered high risk.

All alternatives would have some level of risk related to blockage of LWD at culverts. However, Alternatives 2 and 3 include RMAPs and culvert upgrade requirements that reduce this risk. Blockages at culverts can potentially result in fish passage problems and culvert failure.

The RMZ prescriptions for all of the alternatives have a greater effect on instream conditions in the mid- to long-term (west side: 20 to 60 years; east side: 50 to 100 years) relative to the short-term (west side: less than 20 years; east side: less than 50 years). Currently, most stands (65 percent on west side; 54 percent on east side; Riparian Habitat Section) along fish-bearing streams are in early seral stage. Assuming that these conditions are representative of nearby upslope stands, new rules may not be applied for many years along most streams because timber stands will be too young to harvest economically. In addition, the rate of natural recruitment of functional LWD will initially be low and then increase as riparian stands mature. The recovery of natural LWD recruitment process from the current condition will take from decades to centuries (Bilby and Ward 1989).



Chapter 3

Active wood-placement strategies are important for meeting near-term LWD needs in many fishbearing streams. In fact, streams with low existing levels of LWD and early- to mid-seral riparian stands, may require active placement in order to meet adequate LWD levels over the near term (the next 30 or more years).

Only Alternative 2 provides incentives for instream LWD placement. LWD placement would provide short term benefits to stream systems by providing a more complex habitat structure, nutrient input, and substrate for invertebrate colonization, all of which would benefit fish habitat. These benefits may improve current conditions until the natural riparian corridor can regenerate and provide consistent inputs of LWD. Many Washington streams currently have low levels of instream LWD and adjacent riparian stands are early- to mid-seral. Thus, LWD placement may be the only way to achieve adequate instream LWD levels over the next 30 or more years.

The development of methods for placing large woody debris is fairly advanced (ODF and ODFW 1995), and there would be no significant negative effects to fish from the placement strategies outlined in the Forest Practices Board Manual. The incentive program exists in Alternative 2 for landowners to place wood in stream channels in exchange for removal of additional trees from the outer zone, which have a relatively low probability of naturally recruiting to streams. The relative improvement of current conditions in fish habitat would outweigh the potential risk of loss of LWD from the outer zone over time. The relative addition of wood from the outer zone to the stream channel is a very small percentage and would not provide the same benefits of direct placement of wood within the channel. The major risk of LWD placement is to the transportation infrastructure, including bridges and dams, in the event that structures move from their planned locations.

All of the alternatives allow yarding corridors across RMZs. Yarding corridors provide landowners flexibility in accessing and harvesting suitable timber when a road, stream-crossing, or helicopter yarding would otherwise be required. Requirements for leaving or removing trees cut for yarding corridors would be different under the three alternatives, but these differences in down wood left in the RMZs would be more important for wildlife habitat than aquatic species. Yarding across fish-bearing streams requires a Hydraulic Project Approval (HPA) from WDFW. HPAs provide a regulatory mechanism for requiring mitigation for the yarding corridor and an opportunity for LWD enhancement.

All of the alternatives have a small reduction in LWD potential relative to natural conditions that results from existing stream crossings and stream parallel roads. Alternatives 2 and 3 also include the small landowner exemption that increases the level of risk related to LWD potential in areas with high numbers of small landowners that implement forest practices. Small landowners qualified for the exemption are estimated to own 15 to 20 percent of the private lands in the state and an even small percentage of the total land base (including state and federal lands). See Section 3.4.3.2 for a more detailed discussion of these effects. Existing roads in RMZs and rule exemptions provide a small increase in overall risk of reduced LWD potential relative to natural conditions, but does not substantially change the relative risk among the three alternatives.

All of the alternatives are expected to have increased levels of blowdown along the edges of clearcut units (See Section 3.4.3.2). Blowdown levels should decrease after about five years following harvest unless windstorms are exceptionally mild during that period. Streams with low levels of LWD may benefit in the short-term from increased blowdown rates, but this would also reduce the standing stock of trees available for future recruitment.



Chapter 3

Streams with narrower buffers would likely have a higher proportion of fallen trees that also become instream LWD because the unit edge is closer to the stream.

Leaf and Needle Recruitment

Alternative 1 would provide high risk, Alternative 2 would provide moderate risk, and Alternative 3 would provide very low risk of diminished leaf and needle litter recruitment potential.

The level of risk for reduced leaf and needle recruitment to streams is somewhat analogous to the protection of LWD recruitment, including additional risk related to blowdown, yarding corridors, stream crossings and stream parallel roads, and the small landowner exemption. However, small headwater streams, including seasonal streams that usually flow when leaf litter is at its highest level, have a greater influence on leaf and needle litter recruitment to fish-bearing streams than to LWD recruitment because leaf and needle litter is more easily transported in smaller streams. Furthermore, between 25 and 77 percent of stream miles on forested land are smaller nonfish-bearing streams (Type N or Type 4 and 5). Consequently, the level of protection provided by the alternatives for leaf and needle recruitment would be lower than for LWD. Alternative 1 is expected to provide low protection to streams for leaf and needle recruitment and is considered high risk, Alternative 2 is expected to have a moderate level of risk, and Alternative 3 is considered to be very low risk. Leaf and needle recruitment potential are at slightly higher risk under Alternatives 1 and 2 in the Lower Columbia and southwest regions because 63 and 77 percent of forested streams are smaller nonfish-bearing streams located on state or private ownership affected by Forest Practices Rules.

Floodplains and Off-channel Areas

Alternative 1 would provide high risk to floodplains and off-channel habitats. Alternatives 2 and 3 would protect CMZs in addition to riparian buffers. Alternative 3 would also protect beaver habitat zones (BHZs).

As described earlier, off-channel areas include side channels, backwater alcoves, ponds, and wetlands attached at least seasonally to flowing waters. Off-channel areas can be important habitat seasonally or to particular life stages. Off-channel areas may have shallow, low velocity water that is important during fry rearing periods. These areas can also provide protection from high water velocities during flood flows. Some backwater alcoves and ponds result from groundwater seeps and may have shade levels higher than the main channel. These areas provide cool-water refugia during high summertime temperatures.

Off channel habitat occurs most often in low gradient (less than 4 percent) reaches, but occasionally occur in streams with gradients up to 8 percent. These areas are also in the most active parts of the channel. New off-channel habitats are naturally created within the CMZ which is the area that the stream and any side channels could potentially occupy under existing climatic conditions (Pollock and Kennard, 1998). This section assesses the level of protection the alternatives afford off-channel habitat through protection of the CMZ.

Alternative 1 provides very little protection to the CMZ. Widths of riparian buffers are based entirely on the current location of the active channel. Consequently, any new off-channel habitat that develops after RMZ harvest prescriptions were implemented would potentially have reduced riparian protections. For example, if a new side channel were to develop 25 feet from a Type 2 stream with an average buffer width of 50 feet. The RMZ width to that side channel would effectively be reduced to 25 feet.



Under Alternatives 2 and 3, RMZs are measured from the edge of the CMZ (if present) or the bankfull water's edge. In addition, Alternative 3 RMZs also provide protection for existing beaver ponds or potential beaver habitat. The presence of beaver ponds can be particularly important to coho salmon production (Cederholm et al. 2001). Consequently, existing and potential off-channel habitat has high levels of protection under both Alternatives 2 and 3, but is slightly higher for Alternative 3 because of the added protection for beaver habitat.

Water Temperature

Maintenance of natural water temperature regimes is important for all of the listed salmonid species. As described earlier, changes in water temperatures can have both lethal and sub-lethal effects that can affect the species long-term fitness. Of the seven species considered in this document, bull trout tend to be the most sensitive to water temperature increases and have the lowest temperature requirements.

All of the alternatives have some risk of reduced shade and increased water temperatures related to blowdown, yarding corridors, existing stream crossings, and existing stream parallel roads. Alternatives 2 and 3 also include some added risk related to the small landowner rule exemption described in Chapter 2. These effects are described in more detail in Section 3.4.3.2. This added risk from roads and yarding corridors is expected to be relatively small, but difficult to quantify. The added risk from the small landowner rule exemption is dependent the density of small landowners in a watershed and the rate at which they implement forest practices. Overall, these added risks do not substantially change the relative risk among the three alternatives.

ALTERNATIVE 1

Alternative 1 would provide moderate to high risk of effects on fish bearing stream temperatures.

Under Alternative 1, RMZ widths for the east side and west side do not generally meet the 0.75 SPTH shade criterion for Type 1, 2, or 3 streams under either the 100-year or 250-year SPTH assumptions. Alternative 1 includes a shade rule that describes minimum shade requirements by elevation and water quality class (see Section 3.6), but implementation of the rule under Alternative 1 is restricted to the maximum RMZ width. Type 4 and 5 streams do not receive any protection except under limited circumstances and RMZs are much smaller than needed for full shade protection. Adverse water temperature effects are generally more common in eastside watersheds because the climate is warmer and forest types are generally more open compared to the west side. Overall, Alternative 1 is considered to be at high risk of not meeting salmonid temperature requirements on the east side and at moderate risk on the west side (Tables 3.7-3 and 3.7-4).

ALTERNATIVE 2

For Alternative 2, RMZs for Type S and F streams are wider relative to Alternative 1 and include both no-harvest and selective harvest zones. Under some site class situations (e.g., Option 2 with site class III, IV, or V), the no-harvest portions of the RMZs would provide complete shade, and consequently water temperature protection under the 100-year SPTH assumption. Under some situations, Option 1 could provide slightly less protection than Option 2 because thinning in the inner zone could remove some shade-producing trees closer to the stream. However, under Alternative 2, RMZs must maintain minimum



Chapter 3

canopy closure under the shade rules included in Alternative 1, regardless of the riparian management option chosen by the landowner. Relative to Alternative 1, Alternative 2 improves the shade rule by removing the restriction for the maximum width under which the rule would be implemented. Alternative 2 also provides additional protection for eastside streams within the bull trout distribution by protecting all trees that provide shade to the stream within 75 feet of the channel. Both the shade rule and the bull trout overlay determine shade based upon canopy closure measured with a spherical densiometer which effectively measures most, but not all of the tree shading of direct beam sunlight. In addition, the shade rule protects trees that currently provide shade, but does not take into account the future growth of trees that might eventually provide shade. Consequently, there is some uncertainty about the extent to which these rules would result in higher levels of protection, given the silvicultural prescriptions to be implemented in the core and inner zones. Overall, the risk levels under Alternative 2 for water temperature are considered low for Type S and F westside streams, low to moderate for eastside streams within the bull trout distribution, and moderate elsewhere.

The bull trout overlay is not available on the west side, even though bull trout are present in many westside watersheds. Under Option 1, the largest trees, which likely have the greatest potential to provide shade, would be left in the inner zone. Under Option 2, the lack of the bull trout overlay has no effect because no-harvest buffers would be 80 to 100 feet wide depending upon stream width which are wider than the 75 feet width considered by the bull trout overlay. Overall, the effect of not implementing the bull trout overlay on the west side is expected to be small.

On both the east and the west sides, protection of seeps and springs that provide very cold water is important for bull trout, which have lower temperature requirements compared to other salmonids. Sensitive sites (headwall seeps, side-slope seeps, and alluvial fans) are provided 50-foot no-harvest buffers under Alternative 2 that will provide some thermal protection. In addition, the DOE is considering revisions to Washington State temperature standards (see Section 3.11). These revisions are likely to include species- and lifestage-specific standards to be applied to stream reaches where they are present or expected to be present. Specific standards are likely to be implemented for bull trout. The adaptive management program of Alternative 2 is expected to adjust prescriptions, if necessary, to meet new temperature standards when they are implemented.



Alternative 2 would provide low to moderate risk of effects on fish bearing stream temperatures; however, there is a high degree of uncertainty regarding the effect of no RMZs on many Type N streams on downstream fish streams.

Alternative 2 provides RMZs for at least 50 percent of the length of Type N_p stream reaches, including groundwater seeps and hyporheic zones that would provide cool water. However, no RMZs are required on Type N_p streams for small landowners. Partial protection to narrow Type N_p streams unprotected by buffers can be provided within about 10 years of harvest from the growth of overhanging shrubs and young trees. Some increases in water temperature within Type N_p streams are expected following adjacent timber harvests. Nevertheless, there is still high uncertainty regarding the influence Type N streams on downstream temperatures in Type S and F streams. Type N_s streams do not receive any protection, but this should generally not effect fish because these streams usually do not contain water during hot summer weather.

Overall, Alternative 2 is ranked as having low to moderate risk of not providing adequate water temperature protection on the east side and on the west side. Moderate risk is more likely on the west side in areas where Option 1 is implemented and in lower elevation basins (<1,640 feet) where the possibility of adverse water temperatures is more likely. Moderate risk is more likely on the east side in areas outside of the bull trout overlay.

One area of moderate uncertainty is the effect of nearby clearcuts on air temperatures surrounding streams, even in the presence of shady buffers. Significant increases in air temperatures could lead to negative effects to water temperatures. Another area of uncertainty is the affects of nearby clearcuts on groundwater temperature. Evidence for this effect is not available, but an effect has been hypothesized by Brososke et al. (1997). Under Alternative 2, research conducted as part of adaptive management could reduce the level of uncertainty for these two issues.

ALTERNATIVE 3

Alternative 3 would provide low risk of effects on fish bearing stream temperatures.

Alternative 3 includes no-harvest RMZs for all streams. With the exception of streams greater than 30 percent gradient, the widths of the RMZs are expected to provide full shade protection relative to the 0.75 SPTH criterion. Consequently, Alternative 3 is ranked as having very high protection to provide shade for both eastside and westside watersheds. Alternative 3 also has some uncertainty concerning the effects of upslope clearcuts on stream temperature under shady conditions. However, since RMZs are wider under Alternative 3, the level of risk is low.

Forest Chemicals

The application of pesticides commonly occurs on commercial forestlands to decrease disease from fungal and insect pests and to decrease competition by undesirable vegetation (see Appendix H, Forest Chemicals). Of these three forest chemicals, herbicides are the most commonly used. Application techniques include hand, machine, and aerial spraying. Improper application of pesticides that results in delivery to fish-bearing streams can result in direct acute losses of fish and chronic reductions in fitness through disease, stress, or reduced feeding (Appendix H).



Chapter 3

Alternative 1 would provide moderate risk, Alternative 2 would provide low to moderate risk, and Alternative 3 would provide low risk to fish from forest pesticide applications.

Under Alternative 1, flowing streams and other areas with surface water have a 25-foot or 50-foot buffer that excludes machine or aerial spraying, respectively. However, no buffers are required for hand spraying. Under Alternatives 2 and 3, buffers for aerial application will include the inner zones for fish-bearing waters plus an additional buffer (up to 325 feet) and offset (up to 50 feet) dictated by wind conditions and application height. Type N streams with flowing water will have buffers ranging from 50 to 100 feet depending upon wind conditions and application height. However, Alternative 2 would allow spraying directly on seasonal streams without surface water. Consequently, persistent chemicals could be delivered to fish-bearing stream when flowing waters return. In addition to buffers, Alternative 3 requires that all plants with cultural value be protected from pesticides and that no pesticides be used within 50 feet of all typed streams, including hand spraying.

In comparing the alternatives, it should be recognized that evidence of acute or chronic negative effects of forest pesticide use to fish under current FPRs (Alternative 1) is generally lacking. However, it is also clear that many of the commonly used pesticides have severe effects under laboratory conditions and if improperly used, applied during adverse conditions, or otherwise are allowed to enter fish-bearing waters at toxic concentrations, these effects could be realized in the environment. Consequently, the use of many pesticides in some areas requires a Class IV-special permit (WAC 222-16-070) under all alternatives.

Based primarily upon required buffer widths, Alternative 1 is considered to have low to moderate risk from negative effects to fish while Alternatives 2 and 3 are expected to have low risk. Some uncertainty is present under Alternative 2 because implementation of buffer widths relies entirely on the skill and professional judgment of the pilot applying the pesticide. Implementation of the buffers requires that pilots accurately judge wind speed, wind direction relative to the stream, and distance from the stream. In addition, direct spraying is allowed on Type N_s streams and persistent pesticides could eventually be transported to fish-bearing waters. Alternative 3 would have very high protection because all spraying is eliminated within 50 feet of all streams. The requirement under Alternative 3 that plants with cultural value be protected is problematic for implementation of the prescription. It is unclear which plants are considered to have cultural value and how they will be identified and protected in the field. Consequently, it is possible that for areas where extensive field surveys would be required to protect plants of cultural value, aerial pesticide spraying could be eliminated as a practical application technique.

Fish Passage

Concerns for fish passage on commercial forestlands usually refer to passage through culverts at stream crossings. Historically, concerns were also raised about large log jams which led to stream cleaning programs in some western states (Maser and Sedell, 1994). However, the concerns over passage at log jams were later found to be unrealistic and stream cleaning programs were actually detrimental in many areas. Reduced fish passage or complete blockages at culverts are usually the result of undersized culverts or culverts



Little difference in fish passage protection is present among the three alternatives for new roads because all crossings require HPAs from the Washington Department of Fish and Wildlife.

with water velocities too high for their length, sub-optimal placement relative to stream grade and aspect, and lack of downstream holding pools (Hicks et al., 1991).

Salmon and trout have a powerful instinctual desire to move upstream during spawning migrations which leads them to pass seemingly insurmountable obstacles such as waterfalls. However, biological and physical limitations can restrict their movements. These limitations include burst swimming speed and duration, leaping ability, and water velocities and depth. Factors that effect burst swimming speeds and duration include fish size and condition. Larger fish can swim faster and fish approaching senescence have reduced capacity or require longer rest periods between bursts. Leaping ability is a combination of swimming speed and the availability of suitably sized pools from which to leap. Optimally sized pools allow the fish to reach maximum speed at the proper angle to make the leap. Swimming speeds and water velocities determine the length of pipe through which a fish can successfully maneuver.

Culverts become barriers when their physical characteristics exceed the capacity of fish biology. Barriers can occur to both juveniles moving upstream and downstream and adults primarily moving upstream. Common problems include perched outlets with unsuitable leaping pools, culverts that become dry during summer months, culverts that are too long, culverts with high gradients resulting in high water velocities, and culverts with inadequate resting places. In addition, undersized or poorly constructed culverts that blowout during peak flows can become obstacles until fixed.

Little difference in the protection of fish passage is apparent among the three alternatives for the construction of new roads. Under Alternative 2 and 3, changes in stream crossing standards specific to anadromous fish passage (WAC 222-24-040 Paragraph 3) are deleted from the rules and standards are deferred to WDFW as part of a HPA as defined in the Hydraulics Code (WAC 220-110). HPAs are also required under Alternative 1. Consequently, the alternatives are essentially equivalent.

Substantial differences are present among the alternatives for identifying and modifying or replacing existing culverts that are passage barriers. As mentioned earlier, criteria for the construction of stream crossing structures under current regulations are currently based, in part, on whether a stream is fish-bearing (WAC 222-24-040). For example, culverts must be a minimum diameter of 24 inches for streams with anadromous fish and a minimum diameter of 18 inches for streams with resident game fish. Therefore, the assumptions made in determining a fish-bearing stream are critical for evaluating whether existing stream crossings meet FPRs.

The current DNR classification system has five categories:

- Type 1—All waters inventoried as “shorelines of the State”; highly productive fish-bearing waters
- Type 2—Highly productive fish-bearing waters not designated as Type 1 streams
- Type 3—Fish-bearing waters with substantial populations
- Type 4—Perennial streams without substantial fish populations



Chapter 3

- Type 5—Nonfish-bearing intermittent streams

Numerous additional criteria based upon channel width, gradient, flow, size of impoundment (if present), and level of domestic use are utilized to categorize a stream (WAC 222-16-030). Recent checking of this classification system has shown that many fish-bearing waters were mistyped as nonfish-bearing waters. Therefore, under Alternative 1, some passage problems could occur as a result of stream typing errors.

Under Alternative 1, the current stream typing criteria would continue because there would be no systematic upgrade of culverts with fish passage problems. Some culverts would be identified and fixed as part of watershed analysis, but watershed analysis is voluntary for private landowners. Consequently, problem culverts could remain as passage barriers until a forest practices application was received for a nearby harvest or the state identified the problem through a state-sponsored watershed analysis. Based upon the forest practices application or watershed analysis, the DNR could then require improvements to or replacement of problem culverts. Alternatives 2 and 3 both would require new stream typing systems that would increase the number of streams typed as fish-bearing and would expedite correction of fish passage problems.

Changes in stream typing systems under Alternatives 2 and 3 would increase the stream miles classified as fishbearing.

Under Alternative 2 a new stream typing system would be implemented for state and commercial forestlands (see Appendix C). The new system will include:

- Type S: All waters inventoried as “shorelines of the State”;
- Type F: Waters not classified as Type S, which contain fish habitat; and
- Type N: Waters not classified as Type S or F, which do not contain fish habitat and are either perennial streams (Type N_p) or intermittent (Type N_s)

Determination of default Type F waters lacking ground-truthing will occur using a model, currently under development, that is likely to include stream gradient, drainage size, and other factors. Type F waters are likely to include all streams currently categorized as Type 2 and Type 3, plus a portion of Type 4 streams. Consequently, the number of stream miles assumed to be fish-bearing will expand considerably under Alternative 2 compared to Alternative 1. Notably, Type F waters do not require fish presence, but do require fish habitat that could be used if fish were present. Errors in stream types from the model can be corrected based upon field observations.

Alternative 3 would also implement a new stream typing system based upon geomorphic characteristics:

- Type 1: <20 percent gradient; all fish-bearing streams and other channels are considered important for fish.
- Type 2: 20 to 30 percent gradient; channels are considered important for coarse sediment storage and as sources of LWD.
- Type 3: >30 percent gradient; channels are considered prone to channelized landslides and as sources of LWD.



Under Alternatives 2 and 3, flow condition criteria at culverts appear adequate for most species, but may be too high for trout under some circumstances.

Under Alternative 2, landowners would be required to upgrade road networks to current standards within 15 years and a road maintenance and abandonment plan must be prepared within 5 years. Alternative 3 also includes road plans, but upgrades would be required within 10 years. Included in the revised Forest and Fish Emergency Rules Board Manual (FPB, 2000) are flow condition criteria for a given culvert length and fish species, and specific requirements for prioritizing roadwork based upon fish passage. Passage criteria in the Emergency Rules for fish through culverts appear adequate for most species and life stages when compared to criteria reported by Powers and Orsborn (1984). However, water velocity criteria for trout are 50 to 100 percent higher than criteria reported in Powers and Orsborn (1984). Consequently, passage protection may not be adequate under all circumstances for trout.

Based upon the sample sections, the eastside state and commercial forestlands include 9.7 percent of culverts on fish-bearing streams (Types 1 to 3) under Alternative 1 while the west side has 12.5 percent fish-bearing streams (Table 3.7-8). Based upon proposed changes in stream typing systems, Alternative 2 (Types F and S) would have 27.6 percent and 17.9 percent of culverts identified as being on fish-bearing streams for the east side and west side, respectively. The proportions for Alternative 2 and 3 are similar because not all streams less than 20 percent gradient were assumed to be fish-bearing, only Type F and S. Under Alternatives 2 and 3, higher scrutiny and potential upgrades for fish passage would occur on 5.4 percent more streams on the west side and 17.9 percent on the east side. In combination, the new plans, passage criteria, and stream-typing systems should result in substantial improvements in fish passage within the next 10 to 15 years for Alternatives 3 and 2, respectively, with the largest amount of restoration occurring in east side forests.

Table 3.7-8. Percentage of Stream Crossings on Fish-bearing and Nonfish-bearing Streams by Alternative

Alternative	Westside		Eastside	
	Fish-bearing	Nonfish-bearing	Fish-bearing	Nonfish-bearing
1	12.5	90.3	9.7	87.4
2	17.9	82.1	27.6	72.4
3	17.9	82.1	27.6	72.4

Fish-bearing includes Stream Types 1, 2, and 3 for Alternative 1 and Types F and S for Alternatives 2 and 3.

Neither Alternative 2 or 3 require upgrades to all culverts. Upgrades will be required based upon the effect of a culvert on public resources. If no negative effects are present from a culvert, then the culvert will not require replacement until the end of its life.

FISH PASSAGE: CONCLUSION

Based upon the discussion above, Alternative 1 is considered to have a high level of risk for fish passage. Under Alternative 1 substantial amounts of spawning and rearing habitat will continue to be underutilized by listed salmonids. Both Alternatives 2 and 3 provide substantially more protection than Alternative 1 and are considered to have low risk, with the possible exception of trout under some high-flow circumstances. Notably, changes in



Chapter 3

the stream typing system under both Alternatives 2 and 3 would result in more streams being typed as fish-bearing. Alternative 3 provides slightly more protection than Alternative 2 because it accelerates the schedule for implementing RMAPs and requires a cap on road densities. Flow condition criteria, in culverts, for trout are higher than reported in some of the scientific literature. Additional research is recommended to determine if criteria used in the Emergency Rules are adequate for the protection of trout passage.

3.7.3.3 Synthesis

This section is designed to provide a regional perspective of the alternatives, and a discussion on how they might affect the status of priority fish species found in the regions. Numerous factors, including forest practices, affect the abundance and distribution of Pacific salmon and trout. Other factors such as urbanization, agriculture, fish harvest, hatchery management practices, ocean conditions, and dams for hydroelectricity, flood abatement, irrigation, and drinking water all contribute in varying strengths to the current status of listed fish species. NMFS suggest in their listing documents (see Table 3.7-1) that human-influenced changes in all of these factors (except perhaps ocean conditions) will be required to progress towards a regional recovery of these species. Depending upon the watershed, each of the factors will have more or less influence on the recovery of any listed species in that watershed. Consequently, in any individual watershed, Forest Practices Rules may be either major or minor influences on the salmonids in that watershed.

Relative to other factors influencing their status, Forest Practices Rules have a large effect on bull trout because populations are found predominantly in forested areas upstream of major hydroelectric dams and in agricultural and urbanized areas. Most bull trout populations are not anadromous. Marine conditions, therefore, have little to no influence on populations (other than potentially affecting regional climate).

The analysis in this section is based upon the assumption that factors unrelated to forest practices may prevent attainment of robust, harvestable populations of salmonids even if the prescriptions in the EIS alternatives were 100 percent effective, and the first two goals under the purpose and need were met. Under the first goal, private timber companies can comply with ESA by avoiding take, or obtaining protection under Section 10 or Section 4(d) of ESA. ESA does not require private parties to recover listed species. Goal 2 is to restore and maintain riparian habitat on nonfederal forest lands to support a harvestable supply of fish. It is possible to meet this goal even if other factors prevent salmonids from utilizing this habitat. Some salmonid populations could be extirpated in the future because of non-forest practice-related factors. This assumption is necessary because integration of all the various factors and their range of possible future outcomes is highly speculative and would require a level of detail and site specificity far beyond the scope of this analysis.

The analysis area covers about 39 percent (9,483 square miles) of lands on the west side and about 15 percent (6,287 square miles) of lands on the east side of Washington state. This is a significant amount of land for both regions of the state. Areas with larger amounts of forestland and timber harvest activities should roughly have proportionally larger potential effects on listed salmon and trout because of FPRs. However, this simple

Forest practices are among many factors affecting the status of listed fish species. Improvements in FPRs alone are unlikely to lead to recovery of listed fish species in most areas.



relationship is complicated by mixed ownership and mixed management objectives in most parts of the state. As indicated earlier, few lands or priority fish are affected by FPRs in the Islands and Columbia Basin regions because these regions have few fish-bearing streams or are mostly non-forested. Consequently, it is unlikely that FPRs will have any effect on the recovery of any listed species in these two regions.

Within all regions, implementation of Alternative 1 would likely continue habitat degradation in some forested regions and contribute to any further declines in listed species living in these areas. In contrast, Alternative 2 is considered to have moderate to high protection, and Alternative 3 is considered to have high to very high protection. One major improvement under Alternatives 2 and 3 is that CMZs are provided more protection because RMZs begin at the edge of CMZs rather than from the ordinary high water mark boundary as practiced under Alternative 1. Alternatives 2 and 3 both include monitoring and adaptive management, albeit in slightly different forms (see Appendix I). Consequently, both of these alternatives could be equitable and include high levels of protection in the long-term, based upon future changes in prescriptions.

Monitoring and adaptive management are important tools needed to ensure Alternatives 2 and 3 would achieve desired future conditions over the long-term.

Alternative 3 would implement the widest no-harvest buffers, includes an accelerated schedule for RMAPs, and provides a cap on road densities. Consequently, it has the highest level of long-term protection of the three Alternatives. However, in contrast to Alternative 2, Alternative 3 does not provide incentives to landowners to accelerate the recovery of some streams through active LWD placement strategies or thinning of overstocked riparian stands. These strategies are allowable under Alternative 3 provided the landowner obtains a Class IV–special permit or hydraulic project approval, but there is little to no economic incentive to implement these strategies.

All of the alternatives will include watershed analysis. Alternatives 2 and 3 improves upon current watershed analysis methods by adding modules for cultural resources and stream restoration activities, and makes improvements in the hydrology and water quality modules. Alternative 3 would also include a module for monitoring watershed conditions and prescription effectiveness. A major difference is that Alternative 2 would delete the prescriptive phase of the riparian analysis while the phase would continue under Alternative 3. Under Alternative 2, the prescriptive phase would not be needed, based upon the assumption that standard rules would be effective for preventing cumulative effects. This is a moderate to high-risk assumption because prescriptions under Alternative 2 do not include a watershed-level perspective. Under Alternative 2, effectiveness monitoring under adaptive management program and focused in representative watersheds is assumed to result in a better understanding of the effects of forest practices on salmonids and their habitat. The adaptive management program is also assumed to implement any needed changes in prescriptions to maintain adequate levels of protection. Failure of these assumptions would be detrimental to the recovery of listed species even if individual forest prescriptions appear adequate. If standard rules provide all the necessary certainty to landowners concerning activities on their lands, the benefits of voluntary watershed analysis may not outweigh the costs to private landowners. Because prescriptions are generally equivalent or more conservative under Alternative 3, the likelihood of voluntary completion of watershed analysis by landowners is probably about the same under



Chapter 3

Alternative 3 as Alternative 2. Nevertheless, watershed analysis will eventually be completed for all watersheds, but will likely require a longer period for completion. Watershed analysis, when implemented, will continue to be important for obtaining and organizing baseline information needed for monitoring.

Changes in FPRs under Alternatives 2 and 3 will have the greatest influence on the long-term recovery of the species rather than the short-term. Improvements in road management practices and road upgrades should be apparent first, particularly related to fine sediment which influences the survival of incubating salmon and trout eggs, and fish passage through culverts. A reduction in the frequency and magnitude of mass wasting events that deliver coarse sediment to streams should become apparent. However, some streams may require many years (20 to 100 years or more) to adjust to historical deposits of coarse sediment. Similarly, LWD recruitment is a long-term process. Moderate levels of recovery may require 80 years or more in areas with early-seral stage riparian stands. Some stands will require longer periods to obtain key pieces without some form of management such as thinning or removal of hardwoods. Consequently, in severely degraded forested areas, it is unlikely that fish habitat conditions will improve substantially in the near term (less than 20 to 40 years) without enhancement.

Puget Sound

The Puget Sound region is the most urbanized region in the state.

Chinook salmon and bull trout are listed as threatened in the region plus a summer run of chum salmon that is found in Hood Canal. Coho salmon is a candidate species. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. Many of the lowland areas of the region are highly urbanized. This region is the most heavily populated region of the state with 386 square miles (about 3 percent) of the land categorized as urban growth areas. FPRs regulate commercial timber activities on about 34 percent (4,464 square miles) of the lands in the region while the federal government manages about 34 percent (4,418 square miles) and the DNR manages about 8 percent (997 square miles) under their HCP. All of the major river systems in the region have hydroelectric and/or drinking water dams and reservoirs. Overall, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of the listed species. However, because non-forest related activities also have a large effect on these species, it is unlikely that changes in FPRs, by themselves, would lead to the recovery of these species. Changes in FPRs would likely have the largest effect on bull trout because they are predominantly found in forested areas and are influenced less by marine factors, harvest, hatcheries and urbanization.

Olympic Coast

DNR lands in the Olympic Coast region are managed under the state's HCP.

All of the priority species are present in the Olympic Coast Region (Figures 1 to 3). Bull trout are listed as threatened throughout the region and the Ozette Lake population of sockeye salmon is listed as threatened. Coho salmon is a candidate species. Of the 4-Hs, habitat appears to be the highest priority factor for bull trout. The hydroelectric facilities present in the region are not considered a major issue in general, although one or more dams may be important in specific basins. No hatcheries are stocking bull or sockeye salmon in the region. FPRs regulate commercial timber activities on about 26 percent (705

Chapter 3



square miles) of the lands in the region. An additional 38 percent (1,032 square miles) of the land is managed by the Federal Government (mostly National Forest and National Park in higher elevations) and 17 percent (464 square miles) are managed under the DNR's Habitat Conservation Plan. Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of the listed or potentially listed species, particularly bull trout, but other protection and recovery programs in the region would also have a large influence. The distribution of listed sockeye salmon is restricted and NMFS status review cited several major non-forestry related factors including non-native introductions, ocean conditions, and harvest affecting their status. Nevertheless, Nehlsen et al. (1991) also indicated forest practices in the 1940s and 50s may have contributed to their decline. Consequently, improvements in FPRs could have a positive effect on their recovery.

Southwest

Improvements in FPRs under Alternatives 2 and 3 would likely have a significant effect in the Southwest Region because a large proportion of lands are in private commercial forest management.

All of the priority species are present in this region except sockeye salmon. Only bull trout and sea-run cutthroat trout are listed in the region, but coho salmon is a candidate species. Similar to the Olympic Coast Region, habitat degradation appears to be the leading factor influencing listing of species in the region. A few hydroelectric projects are present in the region, but they are not considered a major issue and no hatcheries are stocking bull trout. FPRs regulate commercial timber activities on about 70 percent (2,493 square miles) of the lands in the region. The state manages an additional 11 percent (374 square miles) of the land under their HCP. Federal forestlands include about 203 square miles or 6 percent of the land. Consequently, the improvements to FPRs under Alternatives 2 and 3 are likely to have a significant effect on the recovery of the listed or potentially listed species with only a moderate level of influence from other land-use practices.

Lower Columbia River

FPRs regulate forest activities on nearly half of the lands in the Lower Columbia region.

All of the priority species are present in this region. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook salmon, chum salmon, and steelhead are listed, and present downstream of Mossyrock Dam and Merwin Dam on the Cowlitz River and Lewis River, respectively plus other tributaries and the mainstem Columbia River. Bull trout are listed as threatened throughout the region where they are present and sea-run cutthroat trout are also listed as threatened. Coho salmon is a candidate species. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. FPRs regulate commercial timber activities on about 45 percent (2,179 square miles) of the land in the region. The DNR manages an additional 9 percent (433 square miles) of land under their HCP. About 32 percent (1,562 square miles) are under Federal management. Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of the listed or potentially listed species, but improvements in other factors are probably needed as well.

Middle Columbia River

Improvements in FPRs would be important for fragmented bull trout populations in the Middle Columbia River Region.

All of the priority species are present in this region, except chum and sea-run cutthroat trout. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook and chum salmon are listed in the westernmost portions of



Chapter 3

this region as part of the lower Columbia River ESU, and steelhead are listed as threatened throughout the region except for the White Salmon River. Bull trout are listed as threatened throughout the region. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. FPRs regulate state and private commercial timber activities on about 13 percent (1,360 square miles) of the lands in the region. The Federal government manages slightly more land (18 percent, 1,810 square miles). Agriculture is an important land-use within the region, particularly within the Yakima Valley and irrigation diversions have been cited as a major concern in the region. Several major dams are also present in the region for hydroelectricity (Bonneville, The Dalles, John Day) and irrigation (Cle Elum, Kachees, Keechelus, Rosa). Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a moderate overall effect on the recovery of the listed or potentially listed species. Changes in FPRs would likely be a major factor in the recovery of bull trout in the region because they are predominately found in forested areas and are influenced less by marine factors, dams, commercial harvest, hatcheries and urbanization. Improvements in FPRs would also be significant for the recovery of chinook salmon and steelhead, however improvements in other land-use practices will also likely be required for successful recovery.

Snake River

FPRs regulate only a small proportion of lands in the arid Snake River Region.

Chinook salmon, sockeye salmon, steelhead and bull trout are present in the region. However, sockeye salmon do not spawn or rear in the region but use the mainstem Snake River as a migration corridor. Chinook, steelhead, and bull trout are listed as threatened within the region. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. However, the region is relatively arid and only about 5 percent (346 square miles) of the lands are regulated by FPRs. Federal management occurs on about 7 percent of the land (491 square miles). The state manages a very small amount of forestland (about 32 square miles) in the region. Nearly 88 percent (5,941 square miles) of the land in this region is unforested. A significant portion of the fish habitat upstream of this region in Idaho is unavailable to listed anadromous species because of impassable dams (Dworshak, Hells Canyon Complex). Four other major hydroelectric dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) are present along the lower Snake River and are considered by many to be a major influence on the status of chinook salmon, sockeye, and steelhead in the region. Consequently, any improvements in FPRs under Alternatives 2 and 3 would only be a very minor contribution towards the overall recovery of listed species in the region. However, within those areas that do have forest practices, improvements to FPRs should provide benefits to species that live in those areas.

Upper Columbia River downstream of Grand Coulee Dam

FPRs affect forest activities on about 11 percent of the land in the Upper Columbia River Region downstream of Grand Coulee Dam.

The priority species found in the region include chinook salmon, sockeye salmon, steelhead, and bull trout. Chinook (endangered), steelhead (threatened), and bull trout (threatened) are listed within the region. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. FPRs regulate commercial timber activities on about 6 percent (655 square miles) of the lands in the region while Federal management occurs over about 39 percent of the lands (4,073 square miles). State forestlands occur over about 5 percent of the lands (469 square miles). About 47 percent (4,865 square



miles) of the lands are unforested in the region. The region also includes a number of dams for hydroelectricity (Rocky Reach, Wanapum, Priest Rapids, Rock Island, Wells, Chief Joseph, and Lake Chelan). Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a low to moderate overall effect on the recovery of the listed species, and other factors will be important for their recovery. However, the effect of improved FPRs could be significant within the watersheds with commercial and state forestlands. Changes in FPRs would likely have the largest effect on bull trout because they are predominately found in forested areas and are influenced less by marine factors, harvest, hatcheries and urbanization.

Upper Columbia River upstream of Grand Coulee Dam

FPRs only affect bull trout and other resident species in the Upper Columbia River Region upstream of Grand Coulee Dam.

The only priority species present in this region is bull trout, which are listed as threatened. Hydroelectric and irrigation dams that have fragmented bull trout distribution plus habitat degradation has been cited as major factors leading to the listing in this region. FPRs regulate commercial timber activities on about 25 percent (2,685 square miles) of the lands in the region. State forests are present on about 4 percent (440 square miles) of land and Federal management occurs on about 21 percent (2,241 square miles). Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of bull trout in the region.



Chapter 3
